MODEL 42C

CHEMILUMINESCENCE NO-NO$_2$-NO$_x$ ANALYZER

INSTRUCTION MANUAL
P/N 100174-00

$C\epsilon$

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26Apr2004

The 220V option complies with 89/336/EEC directive for electromagnetic compatibility.

REFERENCE METHOD DESIGNATION

The Thermo Environmental Instruments, Inc. Model 42C is designated by the United States Environmental Protection Agency (USEPA) as a Reference Method for the measurement of ambient concentrations of nitrogen dioxide pursuant with the requirements defined in the Code of Federal Regulations, Title 40, Part 53.

Designated Reference Method Number: RFNA-1289-074
EPA Designation Date: December 11, 1989

The Model 42C Chemiluminescence NO-NO$_2$-NO$_x$ Analyzer meets EPA reference designation requirements when operated with the following:

Range	0 - 0.05 to 1.0 ppm
Averaging Time	10 to 300 seconds
Temperature Range	15 to 35°C
Line Voltage	90 to 110 VAC @ 50/60 Hertz
	105 to 125 VAC @ 50/60 Hertz
	210 to 250 VAC @ 50/60 Hertz
Pressure Compensation	on or off
Temperature Compensation	on or off
Flow Rate	0.5 to 1 LPM

RS-232 Interface
With or without the following options:

110	Ozone Particulate Filter
200	Carrying Handle
210	Rack Mounts
300	Internal Zero/Span and Sample/Calibration Solenoid Valves
310	Internal Zero/Span and Sample/Calibration Solenoid Valves with Remote I/O Activation
600	4-20 mA Current Output
750	RS-485 Interface
705	Remote I/O Board
800	Permeation Dryer

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CHAPTER 1
INTRODUCTION

The Model 42C Chemiluminescence $NO-NO_2-NO_x$ analyzer combines proven detection technology, easy to use menu-driven software, and advanced diagnostics to offer unsurpassed flexibility and reliability. The Model 42C has the following features:

- Multi-line alphanumeric display
- Menu-driven software
- Field programmable ranges
- Dual range mode
- Autorange mode
- Multiple analog outputs
- High sensitivity
- Fast response time
- Linearity through all ranges
- Internal sample pump
- Independent $NO-NO_2-NO_x$ ranges
- Replaceable NO_2 converter cartridge
- EPA approved

Thermo Environmental Instruments is pleased to supply this chemiluminescence $NO-NO_2-NO_x$ analyzer. We are committed to the manufacture of instruments exhibiting high standards of performance and workmanship. Service personnel are available for assistance with any questions or problems that may arise in the use of this analyzer.

PRINCIPLE OF OPERATION

The Model 42C is based on the principle that nitric oxide (NO) and ozone (O_3) react to produce a characteristic luminescence with an intensity linearly proportional to the NO concentration. Infrared light emission results when electronically excited NO_2 molecules decay to lower energy states. Specifically,

$$NO + O_3 \rightarrow NO_2 + O_2 + h\nu$$

Nitrogen dioxide (NO_2) must first be transformed into NO before it can be measured using the chemiluminescent reaction. NO_2 is converted to NO by a molybdenum NO_2-to-NO converter heated to about 325^oC.

The ambient air sample is drawn into the Model 42C through the **SAMPLE** bulkhead, as shown in Figure 1-1. The sample flows through a particulate filter, a capillary, and then to the mode solenoid valve. The solenoid valve routes the sample either straight to the reaction chamber (NO mode) or through the NO_2-to-NO converter and then to the reaction chamber (NO_x mode). A flow sensor prior to the reaction chamber measures the sample flow.

Dry air enters the Model 42C through the **DRY AIR** bulkhead, through a flow sensor, and then through a silent discharge ozonator. The ozonator generates the necessary ozone concentration needed for the chemiluminescent reaction. The ozone reacts with the NO in the ambient air sample to produce electronically excited NO_2 molecules. A photomultiplier tube (PMT) housed in a thermoelectric cooler detects the NO_2 luminescence.

The NO and NO_x concentrations calculated in the NO and NO_x modes are stored in memory. The difference between the concentrations are used to calculate the NO_2 concentration. The Model 42C outputs NO, NO_2, and NO_x concentrations to both the front panel display and the analog outputs.
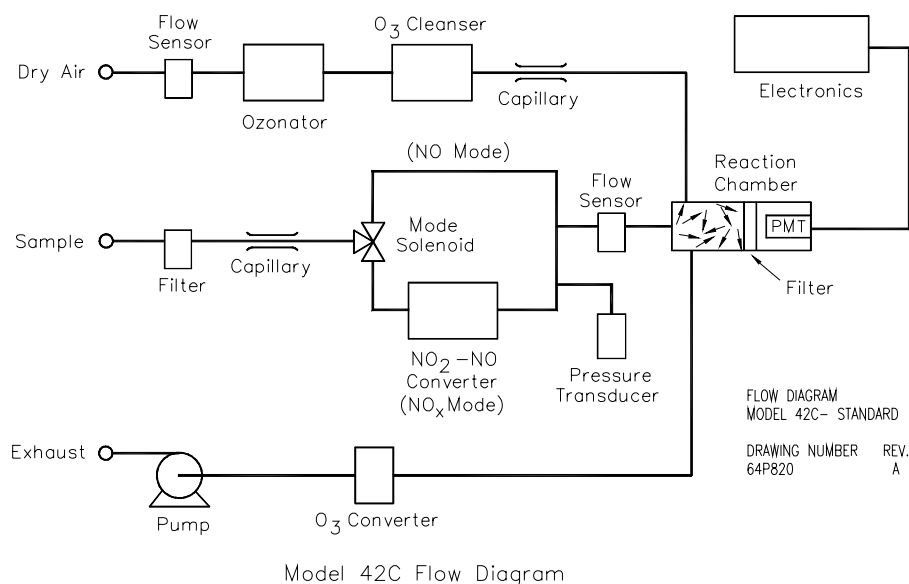
Figure 1-1. Model 42C Flow Schematic

SPECIFICATIONS

Preset ranges	0-0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, and 100 ppm 0-0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, and 150 mg/m^3
Extended ranges	0-0.2, 0.5, 1, 2, 5, 10, 20, 50, and 100 ppm 0-0.5, 1, 2, 5, 10, 20, 50, 100, and 150 mg/m^3
Custom ranges	0-0.05 to 100 ppm 0-0.1 to 150 mg/m^3
Zero noise	0.20 ppb RMS (60 second averaging time)
Lower detectable limit	0.40 ppb (60 second averaging time)
Zero drift (24 hour)	< 0.40 ppb
Span drift (24 hour)	$\pm$1% fullscale
Response time (in automatic mode)	40 sec (10 second averaging time) 80 sec (60 second averaging time) 300 sec (300 second averaging time)
Precision	$\pm$0.4 ppb (500 ppb range)
Linearity	$\pm$1% fullscale
Sample flow rate	0.6 liters/min.
Operating temperature	15 - 35°C (may be safely operated over the range of 0 - 45°C)*
Power requirements	90 -110 VAC @ 50/60 Hz 105-125 VAC @ 50/60 Hz 210-250 VAC @ 50/60 Hz 300 Watts
Physical dimensions	16.75" (W) X 8.62" (H) X 23" (D)
Weight	53 lbs.
Outputs	NO, NO2, and NOx, selectable voltage, 4-20 mA, RS-232, RS-485

* In non-condensing environments

CHAPTER 2
INSTALLATION

The installation of the Model 42C includes lifting the instrument, unpacking the instrument, connecting sample and exhaust lines to the instrument, and attaching the analog outputs to a recording device. To install optional equipment see Chapter 9, "Optional Equipment."

LIFTING

A procedure appropriate to lifting a heavy object should be used when lifting the analyzer. This procedure consists of bending at the knees while keeping your back straight and upright. The analyzer should be grasped at the bottom, in the front and at the rear of the unit. Do not attempt to lift the analyzer by the cover or other external fittings. While one person may lift the unit, it is desirable to have two persons lifting, one by grasping the bottom in the front and the other by grasping the bottom in the rear.

UNPACKING

The Model 42C is shipped complete in one container. If, upon receipt of the analyzer, there is obvious damage to the shipping container, notify the carrier immediately and hold for inspection. The carrier, and not Thermo Environmental Instruments Inc., is responsible for any damage incurred during shipment. Follow the procedure below to unpack and inspect the instrument.

1. Remove the instrument from the shipping container and set on a table or bench that allows easy access to both the front and rear of the instrument.
2. Remove the instrument cover to expose the internal components.
3. Remove any packing material.
4. Check for possible damage during shipment.
5. Check that all connectors and printed circuit boards are firmly attached.
6. Re-install the instrument cover.

SETUP PROCEDURE

1. Connect the sample line to the **SAMPLE** bulkhead on the rear panel (see Figure 2-1). Ensure that the sample line is not contaminated by dirty, wet or incompatible materials. All tubing should be constructed of FEP Teflon®, 316 stainless steel, borosilicate glass, or similar tubing with an OD of ¼" and a minimum ID of 1/8". The length of the tubing should be less than 10 feet.

> **NOTE:** Gas must be delivered to the instrument at atmospheric pressure. It may be necessary to employ an atmospheric bypass plumbing arrangement, as shown in Figure 2-2.

2. Connect the air dryer to the **DRY AIR** bulkhead.
3. Connect the **EXHAUST** bulkhead to a suitable vent or ozone scrubber. If the charcoal ozone scrubber is used, attach the exhaust line to the non-screwtop end of the scrubber. The exhaust line should be ¼" OD with a minimum ID of 1/8". The length of the exhaust line should be less than 10 feet. Verify that there is no restriction in this line. The exhaust stream contains significant concentrations of ozone and oxides of nitrogen.
4. Check the rear panel filter holder for an intact Teflon® particulate filter (2-5 micron).
5. Connect a suitable recording device to the rear panel terminals. See Chapter 3, "Operation" for more information about the pin-out of the rear panel terminal.
6. Plug the instrument into an outlet of the appropriate voltage and frequency.

> **CAUTION:** The Model 42C is supplied with a three-wire grounding cord. Under no circumstances should this grounding system be defeated.
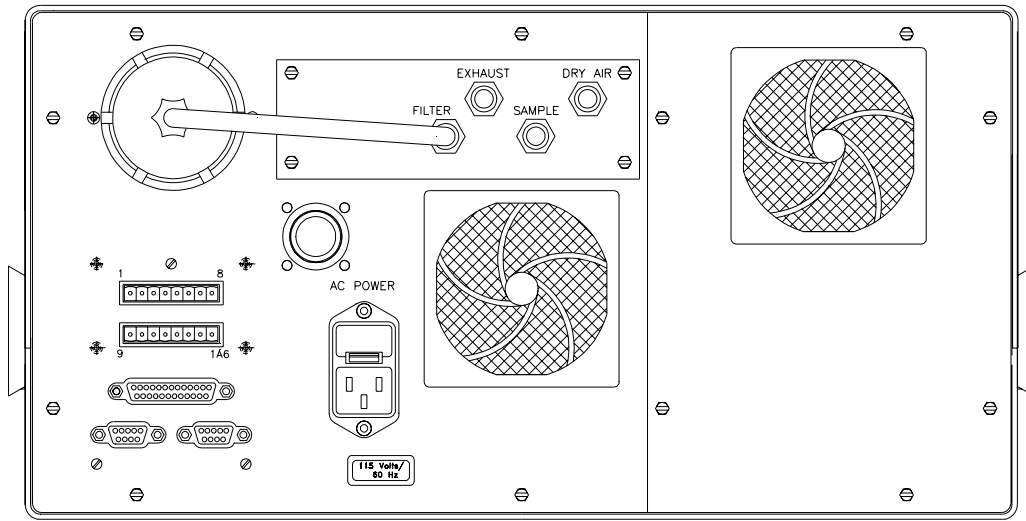
64P7136

Figure 2-1. Model 42C Rear Panel
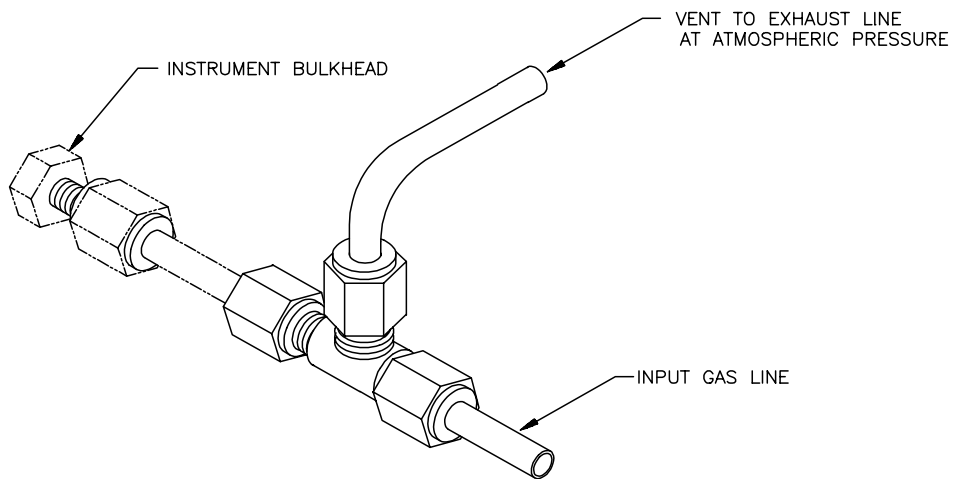
57P753

Figure 2-2. Atmospheric Dump Bypass Plumbing

Analog Output Cover Installation

The analog output cover must be mounted over the analog outputs to comply with 89/336/EEC Directive. This procedure describes how to install the user-supplied analog output cable in the instrument's analog output cover. The following shielded cables or their equivalent are recommended:

Cable	Gauge	No. of Conductors
Alpha #1741C	20	2
Alpha #1746C	18	2
Alpha #5320/2C*	20	2
Alpha #51 52C*	20	2
Alpha #5162C*	18	2
Alpha #1743C	20	4
Alpha 1747/4C	18	4
Alpha #5320/4C	20	4
Alpha #5154C	20	4
Alpha #5164C	18	4
Belden #8208	18	2

* Maximum shielding. Under harsh environments, maximum shielding may be required.

The following tools are required:

    Small screwdriver
    Wire stripper
    Electrical tape or heat shrink tubing

The user-supplied shielded analog output cable must be properly grounded by coming into full contact with the cable clamp (mounted to the analog output cover). To ensure full contact, the shielding must be exposed and folded back over the cable as shown in Figure 2-3.
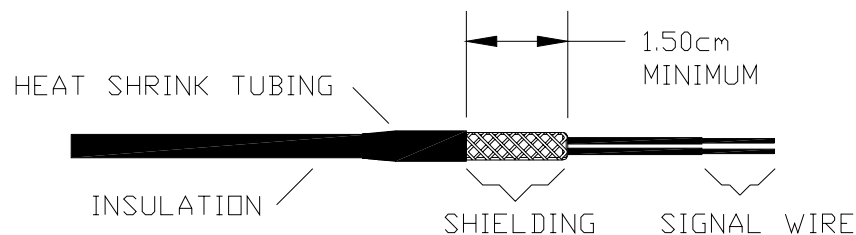
Figure 2-3. Shielded Cable with Shielding Pulled Back

Follow the procedure below to prepare the shielded cable:

1. Remove about 1.8 cm of insulation from the cable.
2. Fold back the shielding.
3. Use electrical tape or shrink tubing to hold the shielding in place. Be sure at least 1.5 cm of shielding is exposed.
4. Strip each signal wire.

Follow the procedure below to connect the shielded cable to the 8-position header:

1. Pass the shielded cable through the cable clamp on the analog output cover, as shown in Figure 2-4.
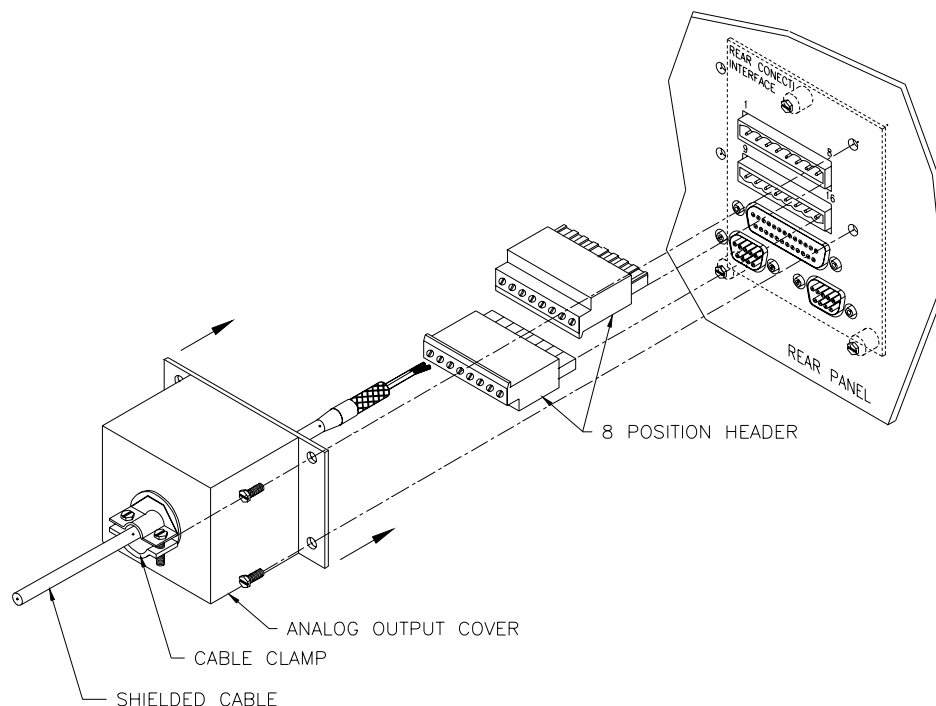
Figure 2-4. Exploded View of Analog Output Cover Installation

2. Insert the bare signal wire into the slot of the header.
3. Tighten down the corresponding set screw.
4. Repeat steps 2 and 3 for each signal wire.
5. Plug the header(s) into the analog output connectors.
6. Install the analog output cover using the four #6 screws with star lockwashers.
7. Position the cable shielding so that it. comes in contact with the cable clamp.
8. Tighten down the cable clamp onto the shielding, as shown in Figure 2-5.
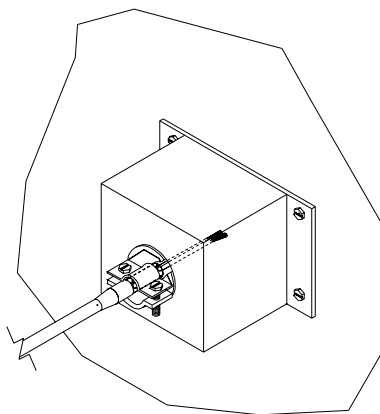
Figure 2-5. Properly Installed Shield Cable

1. Install cable clamp into shield cover and secure. Be sure there is good electrical conductivity between clamp and shield cover.

The following is a parts list of components in the analog output cover assembly:

Part No.	Description	Qty.
7592	Analog output cover	1
11519	8-Position header	2
5889	#6 Star lock washers	4
5820	6-32X3/8" screw	4
14549	Cable clamp	1

STARTUP

1. Turn the power on.
2. Allow 90 minutes for the instrument to stabilize.

> **NOTE**: It is best to turn the ozonator on and let the Model 42C run overnight before calibration in order to obtain the most accurate information.

3. Set instrument parameters such as operating ranges and averaging times to appropriate settings. For more information about instrument parameters, see Chapter 3, "Operation."
4. Before beginning actual monitoring, perform a multipoint calibration as described in Chapter 4, "Calibration."

CHAPTER 3
OPERATION

This chapter describes the front panel display, front panel pushbuttons, and menu-driven software.

DISPLAY

The 4 line by 20 character alphanumeric display shows the sample concentrations, instrument parameters, instrument controls, and help messages. Some menus contain more items than can be displayed at one time. For these menus, use the ↑ and ↓ pushbuttons to move the cursor up and down to each item.

PUSHBUTTONS

Run Pushbutton

The **RUN** pushbutton, shown below, is used to display the Run screen. The Run screen normally displays the NO, NO_2, and NO_x concentrations. In addition, the **RUN** pushbutton is used to switch the optional zero/span and sample solenoid valves. For more information about the optional solenoid valves, see Chapter 9, "Optional Equipment."
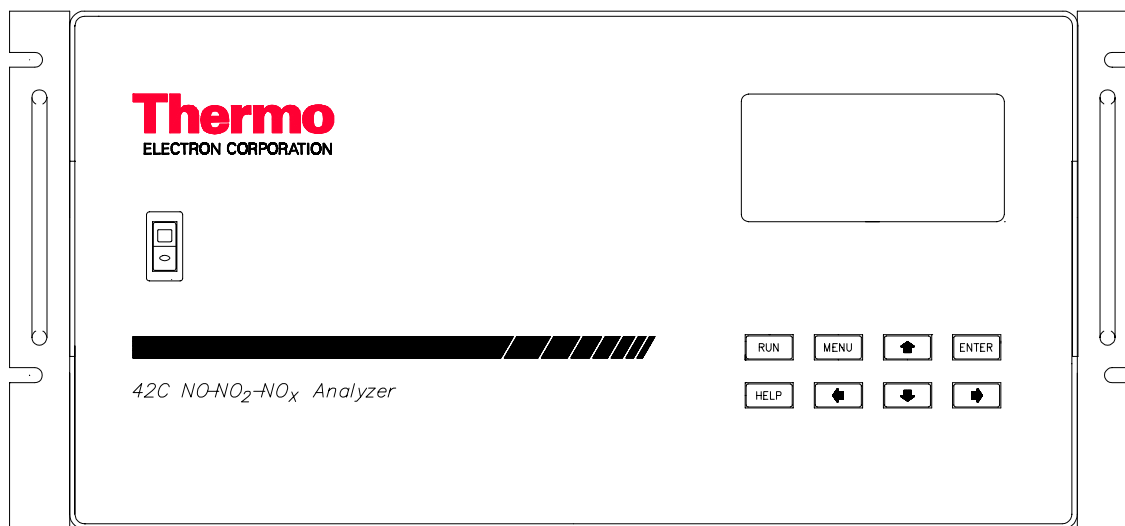
Figure 3-1. Front Panel Pushbuttons   64P7165

Menu Pushbutton

The **MENU** pushbutton is used to display the Main Menu. If the Run screen is not being displayed when this pushbutton is pressed, this pushbutton displays the most recent menu. For more information about the Main Menu, see "Main Menu" later in this chapter.

Enter Pushbutton

The **ENTER** pushbutton is used to choose a menu item, complete an entry, and/or toggle on/off functions.

Help Pushbutton

The **HELP** pushbutton is context-sensitive, that is, it provides additional information about the screen that is being displayed. Press the **HELP** pushbutton for a concise explanation about the current screen or menu. Help messages are displayed using lower case letters to easily distinguish them from the operating screens. To exit a help screen, press **MENU** to return to the previous screen or **RUN** to return to the Run screen.

↑, ↓, ←, → Pushbuttons

The four arrow pushbuttons (↑, ↓, ←, and →) move the cursor up, down, right, and left.

SOFTWARE OVERVIEW

The Model 42C is based on menu-driven software as illustrated by the flowchart in Figure 3-2. The Power-Up and Self-Test screens, shown at the top of the flowchart, are displayed each time the instrument is turned on. These screens are displayed while the instrument is warming up and performing self-checks (press either the **RUN** or **MENU** pushbutton to bypass these screens). After the warm-up period, the Run screen is automatically displayed. The Run screen is the normal operating screen. It normally displays the NO, NO_2, and NO_x concentrations. From the Run screen, the Main Menu can be displayed by pressing the **MENU** pushbutton. The Main Menu contains a list of submenus. Each submenu contains related instrument parameters and/or functions. This chapter describes each submenu and screen in detail. Refer to the appropriate sections for more information.

FLOW CHART– MENU DRIVEN SOFTWARE

DRAWING NUMBER   REV.
64P290   A

Service Mode "On"

Power–up Screen

Self–Test Screen

Run Screen

Main Menu

Range
Gas units
No range
NO2 range
NOx range
Set Custom ranges

Gas units
Hi NO range
Lo NO range
Hi NO2 range
Lo NO2 range
Hi NOx range
Lo NOx range
Set Custom ranges

FOR DUAL OR AUTO RANGE

Average Time
Avg. time(s)

Calibration Factors
NO bkg
NOx bkg
NO coef.
NOx coef.
NO2 coef.
Cal Pressure
NO bkg
NOx bkg
Hi NO coef.
Lo NO coef.
Hi NOx coef.
Lo NOx coef.
Hi NO2 coef.
Lo NO2 coef.
Cal Pressure

Calibration
Cal. NO bkg
Cal. NOx bkg
Cal. NO
Cal. NOx
Cal. NO2
Cal. Pressure
Zero/Span check
Cal. NO bkg
Cal. NOx bkg
Cal. Hi NO
Cal. Lo NO
Cal. Hi NOx
Cal. Lo NOx
Cal. Hi NO2
Cal. Lo NO2
Cal Pressure
Zero/Span check

Instrument Controls
Ozonator
PMT supply
Auto/Manual Mode
Temp. compensation
Pres. compensation
Baud rate
Instrument I.D.
Screen brightness
Service mode
Time
Date

Diagnostics
Program nos.
Voltages
Temps
Pressure
Flow
Test analog outputs
Option switches

Alarm
Internal temp.
Chamber temp
Cooler temp.
Conv. temp.
Pressure
Sample flow
Ozonator flow
NO conc.
NO2 conc.
NOx conc.

Service
PMT supply
Conv. set temp.
Pressure
Sample flow
Zero frequency
A/D frequency
Relay logic
Ozonator safety
Set test display

Figure 3-2. Flowchart of Menu-Driven Software

Power-Up Screen

The Power-Up screen, as shown below, is displayed on power up of the Model 42C.
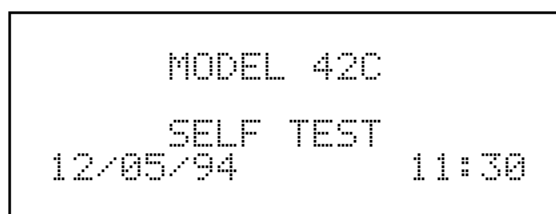
```
┌─────────────────────────────────┐
│  THERMO ENVIRONMENTAL           │
│        INSTRUMENTS              │
│                                 │
│       MODEL 42C                 │
└─────────────────────────────────┘
```

Power-Up Screen

Self-Test Screen

The Self-Test Screen, as shown below, is displayed while the internal components are warming up and diagnostic checks are performed. Press either the **RUN** or **MENU** pushbutton to bypass this screen.

```
┌─────────────────────────────────┐
│        MODEL 42C                │
│                                 │
│       SELF TEST                 │
│  12/05/94          11:30        │
└─────────────────────────────────┘
```

Self-Test Screen

Run Screen

The standard Run screen, as shown below, displays the NO, NO_2, and NO_x concentrations. It also displays time or alarm status, the status of the remote interface and zero/span and sample solenoid valves. When operating in dual or autorange mode two sets of coefficients are used to calculate the NO/NO2/NOx "low" and "high" concentrations. Also, two averaging times are used - one for each range. The display shows as default the low concentrations. If the user presses the "up" arrow the high concentrations are displayed.   Pressing the "down" arrow will display the low concentrations. The letter "l" is displayed when the low values are displayed and "h" when the high values are displayed. For more information about optional equipment see Chapter 9, "Optional Equipment."

```
NO  PPB             62.7
NO2 PPB             25.5
NOx PPB             88.2
          10:25  REMOTE
```

Run Screen

Main Menu

The Main Menu contains a number of submenus as shown below. Instrument parameters and features are divided into these submenus according to their function. Use the ↑ and ↓ pushbuttons to move the cursor to each submenu. When the Main Menu is entered directly from the Run screen, the ← pushbutton may be used to jump to the most recently displayed submenu screen. Use the **ENTER** pushbutton to select a submenu.

```
MAIN MENU:       10:25
>RANGE
 AVERAGING TIME
 CALIBRATION FACTORS


 CALIBRATION
 INSTRUMENT CONTROLS
 DIAGNOSTICS
 ALARM
```

Main Menu

RANGE MENU

The Range menu contains the gas units, NO-NO$_2$-NO$_x$ ranges, and the custom ranges. In the upper right-hand corner of the display, the word single, dual, or auto is displayed to indicate the active mode. The Range menus in the dual and autorange modes appear the same except for the word dual or auto displayed in the upper right-hand corner. For more information about the single, dual or autorange modes, see below.

To display the Range Menu:

➢ From the Main Menu choose Range

To use the Range Menu:

➢ Press the ↑ and ↓ pushbuttons to move the cursor to each choice
➢ Press **ENTER** to select a choice
➢ Press **MENU** to return to the Main Menu
➢ Press **RUN** to return to the Run screen

```
RANGE:          SINGLE
>GAS UNITS         PPB
 NO  RANGE          50
 NO2 RANGE          50
```

```
 NOx RANGE          50
 SET CUSTOM RANGES
```

```
RANGE:            DUAL
>GAS UNITS         PPB
 NO  HI RANGE      100
 NO  LO RANGE       50
```

```
 NO2 HI RANGE      100
 NO2 LO RANGE       50
 NOx HI RANGE      100
 NOx LO RANGE       50
 SET CUSTOM RANGES
```

Range Menu

Single Range Mode

In the single range mode, the NO, NO_2, and NO_x channels each have one range, one averaging time, and one span coefficient. The three analog outputs are arranged on the rear panel terminal strip as shown in Figure 3-3. To use the single range mode, option switches 4 and 5 must be off. For more information about setting the option switches, see "Internal Option Switches," later in this chapter.
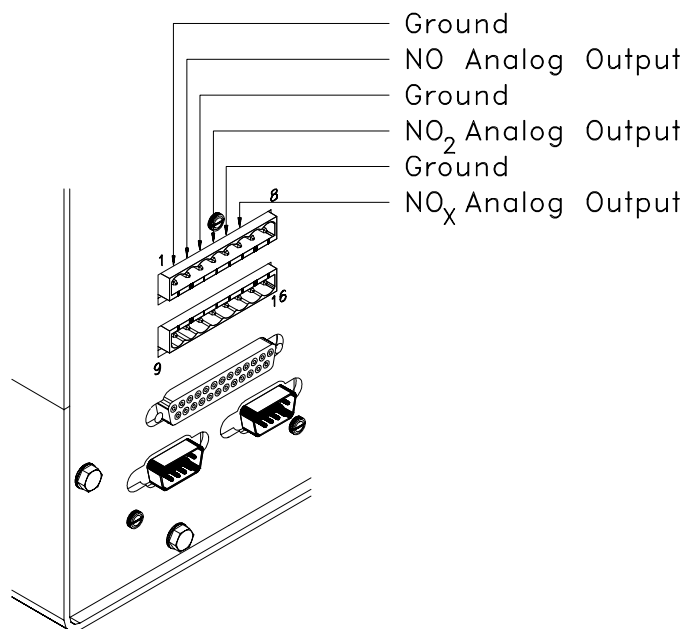
Figure 3-3. Pin-Out of Rear Panel Terminal Strip in Single Range Mode   [64P949-1]

Dual Range Mode

In the dual range mode, there are two independent NO analog outputs and two independent NO_x analog outputs. The NO_2 channel does not have an analog output. However, the NO_2 reading is shown on the display. In the dual range mode, the analog outputs are arranged on the rear panel terminal strip as shown in Figure 3-4.
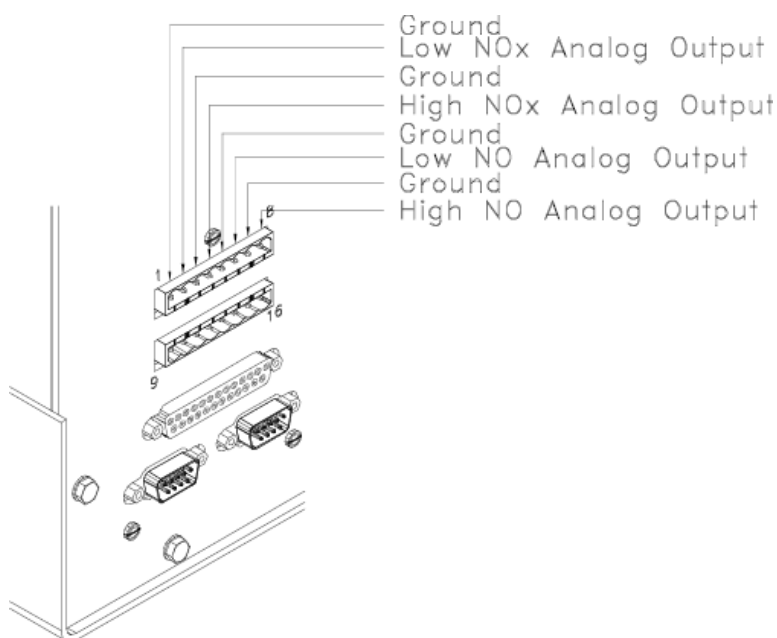
64P949-2

Figure 3-4. Pin-Out of Rear Panel Terminal Strip in Dual Range Mode

The NO channel has two ranges, high NO and low NO, that correspond to the high NO and low NO analog outputs, respectively. The NO_x channel also has two ranges, high NO_x and low NO_x, that correspond to the high NO_x and low NO_x analog outputs, respectively. This enables the sample concentration readings to be sent to the analog outputs using two different ranges. For example, the low NO analog output can be set to output concentrations from 0 to 50 ppb and the high NO analog output set to output concentrations from 0 to 100 ppb. The low NO and high NO range can be set to the same range in order to provide two identical outputs.

In addition to each channel having two ranges, each channel has two span coefficients. There are two span coefficients so that each range can be calibrated separately. This is necessary if the two ranges are not close to one another, e.g., if the low NO range is set to 0-50 ppb and the high NO range is set to 0-20,000 ppb. To use the dual range mode, option switch 4 must be on. For more information about setting the option switches, see "Internal Option Switches," later in this chapter.

Autorange Mode

The autorange mode switches the NO, NO_2 and NO_x analog outputs between high and low ranges, depending on the NO_x concentration level, except when continuous NO mode is active. The high and low ranges are defined in the Range menu. The status outputs are used to indicate which set of ranges, high or low, is being used.
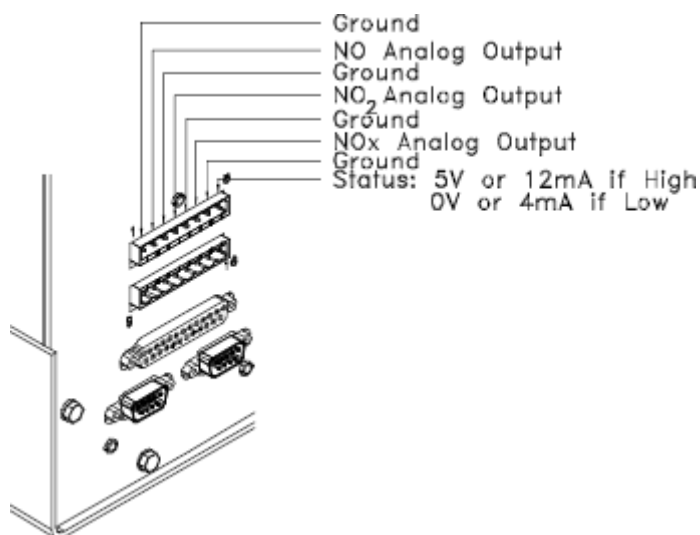
64P949-3

Figure 3-5. Pin-Out of Rear Panel Terminal Strip in Autorange Mode

For example, suppose the low ranges is set to 50 ppb and the high ranges is set to 1000 ppb. Sample concentrations below 50 ppb are presented to the analog outputs using the low ranges. Sample concentrations above 50 ppb are presented to the analog outputs using the high ranges. The status output indicates which ranges are in use. When the low ranges is active, the status output is at 0 volts. When the high ranges is active, the status output is at 50% of full-scale (5V or 12 mA).

When the high ranges is active, the NO_x concentration must drop to 95% of the low NO_x range for the low ranges to become active.

To use the autorange mode, option switches 4 and 5 must be on (see Figure 3-6). For more information about setting the internal option switches, see "Internal Option Switches," later in this chapter.

Gas Units

The Gas Units screen, shown below, defines how the NO, NO_2, and NO_x concentration readings are expressed. Gas units of parts per billion (ppb), parts per million (ppm), micrograms per cubic meter ($\mu g/m^3$), or milligrams per cubic meter (mg/m^3) are available. The $\mu g/m^3$ and mg/m^3 gas concentration modes are calculated using a standard pressure of 760 mm Hg and a standard temperature of 20°C.

When switching from ppb or ppm to $\mu g/m^3$ or mg/m^3, the NO, NO_2, NO_x, and custom ranges default to the highest range in that mode. For example, when switching from mg/m^3 to ppm, all the ranges default to 20 ppm.
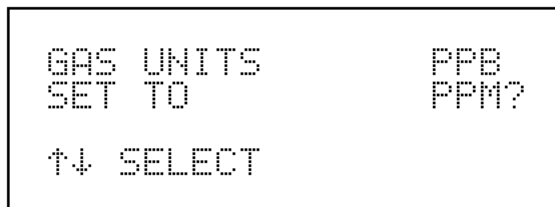
The current gas units are shown on the first line of the display. The gas units are selected on the second line of the display.

To display the Gas Units screen:

> ➢ From the Main Menu choose Range
> ➢ From the Range Menu choose Gas Units

To use the Gas Units Screen:

> ➢ Use the ↑ and ↓ pushbuttons to select the gas units
> ➢ Press **ENTER** to accept the choice
> ➢ Press **MENU** to return to the Range menu
> ➢ Press **RUN** to return to the Run screen.

```
GAS UNITS        PPB
SET TO           PPM?

↑↓ SELECT
```

Gas Units Screen

NO, NO₂, and NOₓ Ranges

The NO, NO₂, and NOₓ ranges define the concentration range of the analog outputs. For example, an NO₂ range of 0-50 ppb restricts the NO₂ analog output to concentrations between 0 and 50 ppb.

The second line of the display shows the current NO, NO₂, or NOₓ range. The third line of the display is used to change the range. The range screen is similar for the single, dual, and autorange modes as shown below. The only difference between the screens are the words Hi or Lo displayed on the first line to indicate which range is displayed. For more information about the dual and autorange modes, see "Single Range Mode," "Dual Range Mode," and "Autorange Mode" earlier in this chapter.

Table 3-1 lists the standard ranges. Table 3-2 lists the extended ranges. To use the extended ranges, option switch 7 must be on. When switching from standard to extended ranges, the PMT voltage must be readjusted. For more information about readjusting the PMT voltage, see Chapter 7, "Servicing."

To display the NO, NO₂, or NOₓ range screen:

> ➢ From the Main Menu choose Range
> ➢ From the Range menu choose NO, NO₂, or NOₓ range

To use the NO, NO₂, or NOₓ range:

> ➢ Use the ↑ and ↓ pushbuttons to scroll through the ranges
> ➢ Press **ENTER** to accept a range
> ➢ Press **MENU** to return to the Range menu
> ➢ Press **RUN** to return to the Run screen.

```
RANGE:
NO PPB          50.0
SET TO         100.0?
↑↓ SELECT
```

```
RANGE:
LO NO PPB       50.0
SET TO         100.0?
↑↓ SELECT
```

Range Screens in Single and Dual/Autorange Modes

Table 3-1. Standard Ranges

ppb	ppm	µg/m^3	mg/m^3	
50	0.05	100	0.1	
100	0.10	200	0.2	
200	0.20	500	0.5	
500	0.50	1,000	1.0	
1,000	1.00	2,000	2.0	
2,000	2.00	5,000	5.0	
5,000	5.00	10,000	10.0	
10,000	10.00	20,000	20.0	
20,000	20.00	30,000	30.0	
C1	C1	C1	C1	
C2	C2	C2	C2	
C3	C3	C3	C3	

Table 3-2. Extended Ranges

ppb	ppm	µg/m^3	mg/m^3	
200	0.2	500	0.5	
500	0.5	1,000	1	
1,000	1	2,000	2	
2,000	2	5,000	5	
5,000	5	10,000	10	
10,000	10	20,000	20	
20,000	20	50,000	50	
50,000	50	100,000	100	
100,000	100	150,000	150	
C1	C1	C1	C1	
C2	C2	C2	C2	
C3	C3	C3	C3	

To use extended ranges, option switch 7 must be on. C1, C2, and C3 are custom ranges. For more information about custom ranges, see "Custom Ranges Menu" below.

Custom Ranges Menu
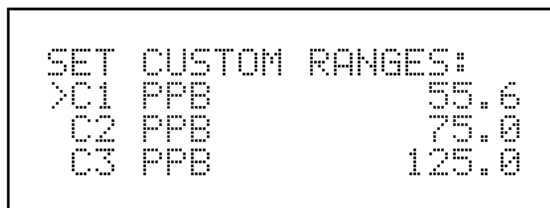
The Custom Ranges Menu, shown below, lists three custom ranges (C1, C2, and C3). Custom ranges are user-defined ranges. In the ppb(ppm) mode, any value between 50 ppb (0.05 ppm) and 20,000 ppb (20 ppm) can be specified as a range. In the $\mu g/m^3$(mg/m^3) mode, any value between 100 $\mu g/m^3$ (0.1 mg/m^3) and 30,000 $\mu g/m^3$ (30 mg/m^3) can be specified. See "Custom Range Screen" below for more information about defining the custom ranges.

To display the Custom Range screen:

> ➤ From the Main Menu choose Range
> ➤ From the Range menu choose Set Custom Ranges

To use the Custom Range menu:

> ➤ Use the ↑ and ↓ pushbutton to move the cursor up and down
> ➤ Press **ENTER** to select the custom range to define
> ➤ Press **MENU** to return to the Range menu
> ➤ Press **RUN** to return to the Run screen

```
SET CUSTOM RANGES:
>C1 PPB          55.6
 C2 PPB          75.0
 C3 PPB         125.0
```

Set Custom Ranges Menu

Custom Range Screen. The Custom Range screen, shown below, is used to define the custom ranges.
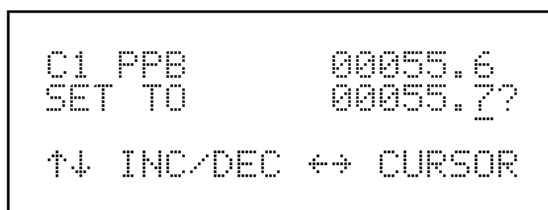
The first line of the display shows the current custom range. The second line of the display is used to set the range. To use the custom full-scale range, be sure to select it (C1, C2, or C3) in the NO, NO_2, or NO_x Range screen. See "NO, NO_2, and NO_x Ranges" above for more information about selecting ranges.

To display the Custom Range screen:

> ➢ From the Main Menu choose Range
> ➢ From the Range menu choose Set Custom Ranges
> ➢ From the Set Custom Range menu choose C1, C2, or C3

To use the Custom Range screen:

> ➢ Use the ↑ and ↓ pushbutton to increment and decrement each digit
> ➢ Use the ← and → pushbutton to move the cursor left and right
> ➢ Press **ENTER** to accept the custom range
> ➢ Press **MENU** to return to the Set Custom Ranges menu
> ➢ Press **RUN** to return to the Run screen

```
┌─────────────────────────────────┐
│                                 │
│  C1 PPB        00055.6          │
│  SET TO        00055.7?         │
│                                 │
│  ↑↓ INC/DEC  ←→ CURSOR          │
│                                 │
└─────────────────────────────────┘
```

Set Custom Range 1 Screen

AVERAGING TIME MENU

The averaging time defines a time period (10 to 300 seconds) during which NO, NO_2, and NO_x measurements are taken. The average concentration of the NO, NO_2, and NO_x readings are calculated for that time period. The front panel display and analog outputs are updated every 10 seconds with the calculated averages. An averaging time of 10 seconds, for example, means that the average concentration of the last 10 seconds will be output at each update. An averaging time of 300 seconds means that the moving average concentration of the last 300 seconds will be output at each 10-second update. Therefore the lower the averaging time, the faster the front panel display and analog outputs respond to concentration changes. Longer averaging times are typically used to smooth output data.
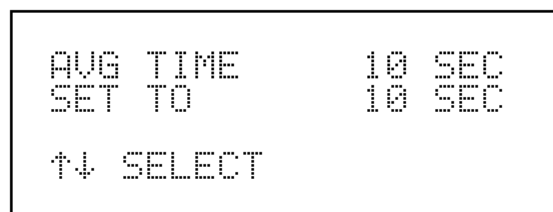
The Averaging Time screen for the single and range mode is shown below. In the dual and autorange mode, an Averaging Time Menu is displayed before the averaging time screen. This menu is needed because dual and autorange modes have two averaging times (high and low). The Averaging Time screen functions the same way in the single, dual and autorange modes. The following averaging times are available: 10, 20, 30, 60, 90, 120, 180, 240, and 300 seconds. Additional averaging times are available in manual NO and manual NO_x modes: 1, 2, and 5 seconds. For more information about the manual mode, see "Auto/Manual Mode" later in this chapter.

To display the Averaging Time menu/screen:

> ➢ From the Main Menu Choose Averaging Time

To use the Averaging Time screen:

> ➢ Use the ↑ and ↓ pushbuttons to select the averaging time
> ➢ Press **ENTER** to accept the averaging time
> ➢ Press **MENU** to return to the Main Menu
> ➢ Press **RUN** to return to the Run screen

```
AVG TIME      10 SEC
SET TO        10 SEC

↑↓ SELECT
```

Averaging Time Screen

CALIBRATION FACTORS MENU

Calibration factors are determined during automatic and manual calibration and are used to correct the NO, NO_2, and NO_x concentration readings. The Calibration Factors menu displays the calibration factors as shown below. Normally the instrument is calibrated automatically, that is, using the Calibration menu described in "Calibration Menu," later in this chapter. However, the instrument can also be calibrated manually using this menu. To manually calibrate the instrument, see "NO and NO_x Backgrounds" and "NO, NO_x, and NO_2 Span Coefficients" and "Cal Pressure" below for more information.

To display the Calibration Factors menu:

> ➢ From the Main Menu choose Calibration Factors:

To use the Calibration Factors menu:

> ➢ Use the ↑ and ↓ pushbuttons to move the cursor up and down
> ➢ Press **ENTER** to go to the Calibration Factor screen
> ➢ Press **MENU** to return to the Main Menu
> ➢ Press **RUN** to return the Run screen

```
CALIBRATION FACTORS:          CALIBRATION FACTORS:
>NO  BKG PPB      0.0         >NO  BKG PPB      0.0
 NOx BKG PPB      0.0          NOx BKG PPB      0.0
 NO  COEF      1.000           HI  NO  COEF  1.000
```

```
 NOx  COEF      1.000          LO NO   COEF    1.000
 NO2 COEF      1.000           HI NO   COEF    1.000
 CAL PRESSURE  200.0           LO NOx  COEF    1.000
                               HI NO2  COEF    1.000
                               LO NO2  COEF    1.000
                               CAL PRESSURE    200.0
```

Calibration Factors Menu in Single and Dual/Autorange Modes

NO and NO$_x$ Background Corrections

The NO and NO$_x$ background corrections are determined during zero calibration.   The NO background is the amount of signal read by the analyzer in the NO channel while sampling zero air. The NO$_x$ background is the amount of signal read by the analyzer in the NO$_x$ channel while sampling zero air. The background signal is the combination of electrical offsets, PMT dark current, and trace substances undergoing chemiluminescence. Before the analyzer sets the NO and NO$_x$ readings to zero, it stores these values as the NO and NO$_x$ background corrections, respectively. The NO$_2$ background correction is determined from the NO and NO$_x$ background corrections and is not displayed. NO and NO$_x$ background corrections are typically below 15 ppb.

The NO and NO$_x$ Background screens are used to perform a manual zero calibration of the instrument. Before performing a zero calibration, allow the analyzer to sample zero air until stable readings are obtained. The NO channel should be calibrated first. Both the NO and NO$_x$ Background screens operate the same way. Therefore, the following description of the NO background screen applies to the NO$_x$ background screen as well. The first line of the display shows the current NO reading. The second line of the display shows the NO background correction that is stored in memory. The NO background correction is a value, expressed in the current gas units, that is subtracted from the NO reading to produce the NO reading that is displayed.

In the example below, the analyzer is displaying 4.4 ppb of NO while sampling zero air. This reading represents a combination of electrical offsets, PMT dark current, and trace substances undergoing chemiluminescence.   A background correction of 0.0 ppb means that 0 ppb is being subtracted from the NO concentration being displayed. Therefore the background correction must be increased to 4.4 ppb in order for the NO reading to be at 0 ppb, i.e., a NO reading of 4.4 ppb minus a NO background reading of 4.4 ppb gives the corrected NO reading of 0 ppb.
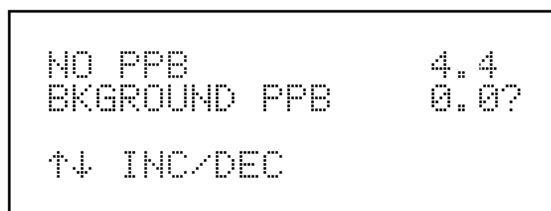
To set the NO reading in the example below to zero, use the ↑ pushbutton to increment the NO background correction to 4.4 ppb. As the NO background correction is increased, the NO concentration is decreased. Pressing the ↑ and ↓ pushbuttons however, has no affect on the analog outputs or the stored NO background correction of 0.0 ppb. A question mark following both the NO reading and the NO background correction indicates that these are proposed changes as opposed to implemented changes. To escape this screen without making any changes, press the **MENU** pushbutton to return to the Calibration Factors menu or the **RUN** pushbutton to return to the Run screen. Press the **ENTER** pushbutton to actually set the NO reading to 0 ppb and store the background correction of 4.4 ppb. Then the question mark prompt beside the NO reading disappears.

To display the NO or NO$_x$ Background screen:

- ➢ From the Main Menu choose Calibration Factors
- ➢ From the Calibration Factors menu choose NO or NO$_x$ Background

To use the NO or NO$_x$ Background screen:

- ➢ Use the ↑ and ↓ pushbuttons to increment/decrement the proposed NO background
- ➢ Press **ENTER** to accept a change in the background
- ➢ Press **MENU** to return to the Calibration Factors menu
- ➢ Press **RUN** to return to the Run screen.

```
┌─────────────────────────────────┐
│                                 │
│  NO PPB            4.4           │
│  BKGROUND PPB      0.0?          │
│                                 │
│  ↑↓ INC/DEC                     │
│                                 │
└─────────────────────────────────┘
```

NO Background Screen

NO, NO$_x$, and NO$_2$ Span Coefficients

The NO, NO$_x$, and NO$_2$ span coefficients are calculated during calibration. The span coefficients are used to correct the NO, NO$_x$, and NO$_2$ readings. The NO and NO$_x$ span coefficients normally have values near 1.000. The NO$_2$ span coefficient normally has a value between 0.960 and 1.050.

The NO, NO$_x$, and NO$_2$ Span Coefficient screens enable the NO, NO$_x$, and NO$_2$ span coefficients to be manually changed while sampling span gas of known concentration. The NO, NO$_x$, and NO$_2$ Span Coefficient screens operate the same way. Therefore, the following description of the NO span coefficient screen applies to the NO$_x$ and NO$_2$ span coefficient screens as well.

The first line of the display shows the current NO concentration reading. The second line of the display shows the NO span coefficient that is stored in memory and is being used to correct the NO concentration. Notice that as the span coefficient value is changed, the current NO concentration reading on the first line also changes. However, no real changes are made until the **ENTER** pushbutton is pressed. Only proposed changes, as indicated by a question mark prompt, are displayed until the **ENTER** pushbutton is pressed.

To display the NO, NO$_x$, or NO$_2$ Span Coefficient screens:

> ➢ From the Main Menu choose Calibration Factors
> ➢ From the Calibration Factors menu choose NO, NO$_x$, or NO$_2$ Coef

To use the NO, NO$_x$, or NO$_2$ Span Coefficient screens:

> ➢ Use the ↑ and ↓ pushbuttons to increment/decrement the proposed readings
> ➢ Press **ENTER** to accept a change
> ➢ Press **MENU** to return to the Calibration Factors menu
> ➢ Press **RUN** to return to the Run screen

```
NO PPB          51.4
NO COEF       1.000?

↑↓ INC/DEC
```

NO Span Coefficient Screen

Calibration Pressure

The Calibration Pressure is used to account for slight pressure fluctuation brought on by changing weather. The calibration pressure is set equal to the reactor pressure at the time of calibration.
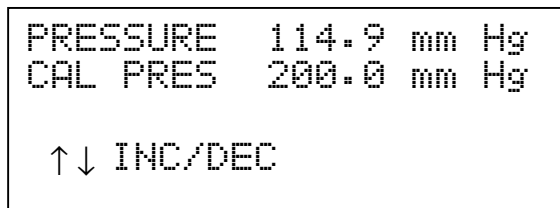
Note: Turning the pressure correction on and off can produce significant artificial jumps in the apparent sample concentration. If the pressure correction feature is to be used, the instrument must be calibrated with the pressure correction feature on. For more information about calibration, see Chapter 4, "Calibration."

To display the Cal Pressure menu:

➢ From the Main Menu choose Calibration Factors
➢ From the Calibration Factors Menu choose Cal Pressure

To use the Cal Pressure screen:

➢ Use the ↑ and ↓ pushbuttons to increment/decrement the Cal Pressure
➢ Press **ENTER** to save the changes
➢ Press **MENU** to return to the Calibration Factors menu
➢ Press **RUN** to return to the Run screen

```
PRESSURE   114.9 mm Hg
CAL PRES   200.0 mm Hg


 ↑↓ INC/DEC
```

CAL Pressure Screen

CALIBRATION MENU

The Calibration menu is used to auto calibrate the backgrounds, the NO, NO_x, and NO_2 channels and to set the calibration pressure. The calibration procedure is the same in dual, auto, or single range, however, there are two sets of gas coefficients in dual or autorange (i.e. low and high coefficients). This enables each range to be calibrated separately. When calibrating the instrument in dual or autorange, be sure to use a low span gas to calibrate the low range and a high span gas to calibrate the high range. In either case, the first step in calibrating the instrument is to assign the "calibration pressure." The "calibration pressure" is used to account for slight pressure fluctuation brought on by changing weather. The "calibration pressure" is set equal to the reactor pressure at the time of calibration. For more information about calibration, see Chapter 4, "Calibration."

To display the Calibration menu:

> ➤ From the Main Menu choose Calibration

To use the Calibration menu:

> ➤ Use the ↑ and ↓ pushbuttons to move the cursor up and down
> ➤ Press **ENTER** to accept the choice
> ➤ Press **MENU** to return to the Main Menu
> ➤ Press **RUN** to return to the Run screen

```
CALIBRATION:
>CALIBRATE NO   BKG
 CALIBRATE NOx BKG
 CALIBRATE NO
 CALIBRATE NOx
```

```
CALIBRATION:
>CALIBRATE NO   BKG
 CALIBRATE NOx BKG
 CALIBRATE HI NO
 CALIBRATE LO NO
```

```
 CALIBRATE NO2
 CALIBRATE PRESSURE
```

```
 CALIBRATE HI NOx
 CALIBRATE LO NOx
 CALIBRATE HI NO2
 CALIBRATE LO NO2
 CALIBRATE PRESSURE
```

Calibration Menu in Single and Dual/Autorange Modes

Calibrate NO bkg

The Calibrate NO bkg screen, shown below, is used to perform a zero calibration. Be sure the analyzer samples zero air until stable readings are obtained. The first line of the display shows the current NO reading.

It is important to note the averaging time when calibrating. The longer the averaging time, the more accurate the calibration will be. To be most accurate, use the 300-second averaging time. For more information about calibration, see Chapter 4, "Calibration."

To display the Calibrate NO bkg screen:

> ➢ From the Main Menu choose Calibration
> ➢ From the Calibration menu choose Calibrate NO bkg

To use the Calibrate NO bkg screen:

> ➢ Press **ENTER** to set the NO reading to zero
> ➢ Press **MENU** to return to the Calibration menu
> ➢ Press **RUN** to return to the Run screen

```
NO PPB         1.2

SET TO       ZERO?
```

Calibrate NO bkg Screen

Calibrate NO$_x$ bkg

The Calibrate NO$_x$ bkg screen, shown below, is used to perform a zero calibration. Be sure the analyzer samples zero air until stable readings are obtained. The first line of the display shows the current NO$_x$ reading.

It is important to note the averaging time when calibrating. The longer the averaging time, the more accurate the calibration will be. To be most accurate, use the 300-second averaging time. For more information about calibration, see Chapter 4, "Calibration."

To display the Calibrate NO$_x$ bkg screen:

> ➢ From the Main Menu choose Calibration
> ➢ From the Calibration menu choose Calibrate NO$_x$ bkg

To use the Calibrate NO$_x$ bkg screen:

> ➢ Press **ENTER** to set the NO$_x$ reading to zero
> ➢ Press **MENU** to return to the Calibration menu
> ➢ Press **RUN** to return to the Run screen

```
NOx PPB        3.4

SET TO        ZERO?
```

Calibrate NO$_x$ bkg Screen

Calibrate NO, NO$_x$, and NO$_2$

The span calibration screens are used to adjust the NO, NO$_x$, and NO$_2$ span concentrations while sampling span gas of known concentration. All calibration screens operate the same way. Therefore, the following description of the NO calibration screen applies to the NO$_x$ and NO$_2$ calibration screens as well.
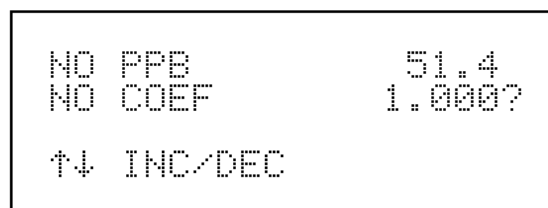
The first line of the display shows the current NO concentration reading. The second line of the display shows the current NO range. The third line of the display is where the NO calibration gas concentration is entered.
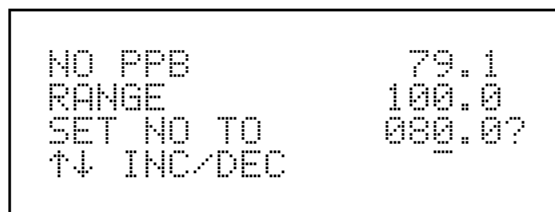
It is important to note the averaging time when calibrating. The longer the averaging time the more accurate the calibration will be. For the most accurate calibration, use the 300 second averaging time. For more information about calibration, see Chapter 4, "Calibration."

To display the Calibrate NO, NO$_x$, or NO$_2$ screen:

> ➢ From the Main Menu choose Calibration
> ➢ From the Calibration menu choose Calibrate NO, NO$_x$, or NO$_2$

To use the Calibrate NO, NO$_x$, or NO$_2$ screen:

> ➢ Use the ↑ and ↓ pushbuttons to increment/decrement each digit
> ➢ Use the ← and → pushbuttons to move the cursor left and right
> ➢ Press **ENTER** to calibrate the NO, NO$_x$, or NO$_2$ channel to the cal gas
> ➢ Press **MENU** to return to the Calibration menu
> ➢ Press **RUN** to return to the Run screen

```
NO PPB          79.1
RANGE          100.0
SET NO TO      080.0?
↑↓ INC/DEC
```

NO Calibration Screen

Calibrate Pressure

The Calibrate Pressure, shown below, is used to set the calibration pressure.
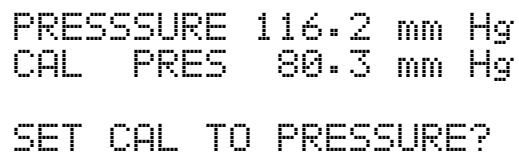
The calibration pressure should be set only when calibrating the instrument.

To display the Calibrate Pressure screen:

➢ From Main Menu choose Calibration
➢ From Calibration menu choose Calibrate Pressure

To use the Calibrate Pressure menu:

➢ Press **ENTER** to set the Calibration Pressure
➢ Press **MENU** to return to the Calibration Menu
➢ Press **RUN** to return to the Run screen

```
PRESSSURE 116.2 mm Hg
CAL  PRES   80.3 mm Hg

SET CAL TO PRESSURE?
```

Calibrate Pressure Screen

INSTRUMENT CONTROLS MENU

The Instrument Controls menu contains a number of items as shown below. The software controls listed in this menu enable control of the listed instrument functions.

To display the Instrument Controls menu:

➢ From the Main Menu choose Instrument Controls

To use the Instrument Controls menu:

➢ Use the ↑ and ↓ pushbuttons to move the cursor up and down
➢ Press **ENTER** to select a choice
➢ Press **MENU** to return to the Main Menu
➢ Press **RUN** to return to the Run screen

```
INSTRUMENT CONTROLS:
>OZONATOR
 PMT SUPPLY
 AUTO/MANUAL MODE
```

```
TEMP COMPENSATION
PRES COMPENSATION
BAUD RATE
INSTRUMENT ID
SCREEN BRIGHTNESS
SERVICE MODE
TIME
DATE
```

Instrument Controls Menu

Ozonator Screen

The Ozonator screen, shown below, is used to turn the internal ozonator on and off. The first line of the display shows the status of the control line that turns the ozonator on and off. The second line of the display shows the user-specified ozonator setting. Under most conditions, the control line status and ozonator set status are the same. However, as a safety precaution, the microprocessor can override the user-specified ozonator setting. This occurs only if the ozonator flow drops below the alarm limit. In this case, an alarm is activated and the ozonator is turned off. This is done to prevent the ozonator from overheating, which will result in permanent damage to the ozonator.

It is possible, however, to defeat this feature, by setting the ozonator minimum alarm setting to 0 LPM. This feature must not be defeated if there is inadequate ozonator flow (less than 0.050 LPM). For more information about the ozonator flow alarm, see "Ozonator Flow" later in this chapter.

The ozonator must be on to obtain NO, NO_2, and NO_x readings. As an additional safety precaution, a lit LED mounted on the Ozonator Board indicates that the ozonator is on.

To display the Ozonator screen:

> ➤ From the Main Menu choose Instrument Controls
> ➤ From the Instrument Controls menu choose Ozonator

To use the Ozonator screen:

> ➤ Use the **ENTER** pushbutton to toggle the ozonator on and off
> ➤ Press **MENU** to return to the Instrument Controls menu
> ➤ Press **RUN** to return to the Run screen

```
OZONATOR          OFF
OZONATOR SET      OFF

SET OZONATOR      ON?
```

Ozonator Screen

PMT Supply

The PMT Supply screen, shown below, is used to turn the PMT power supply on and off. This is useful in a troubleshooting situation.

To display the PMT screen:

- ➢ From the Main Menu choose Instrument Controls
- ➢ From the Instrument Controls menu choose PMT Supply

To use the PMT screen:

- ➢ Use the **ENTER** pushbutton to toggle the PMT power supply on and off
- ➢ Press **MENU** to return to the Instrument Controls menu
- ➢ Press **RUN** to return to the Run screen

```
PMT SUPPLY        OFF
TURN              ON?
```

PMT Supply Screen

Auto/Manual Mode

The Auto/Manual Mode screen, shown below, allows selection of the automatic mode (NO/NO$_x$), NO mode (manual NO), or NO$_x$ mode (manual NO$_x$). The auto mode switches the mode solenoid valve automatically on a 10 second cycle so that NO, NO$_2$, and NO$_x$ concentrations are determined. The manual NO mode puts the mode solenoid valve into the open position so that the sample gas bypasses the NO$_2$-to-NO converter. Therefore, only the NO concentration is determined. The manual NO$_x$ mode puts the mode solenoid valve into the closed position so that the sample gas passes through the NO$_2$-to-NO converter. Therefore, only the NO$_x$ concentration is determined. In the manual modes, additional averaging times of 1, 2, and 5 seconds are available from the Averaging Time screen.
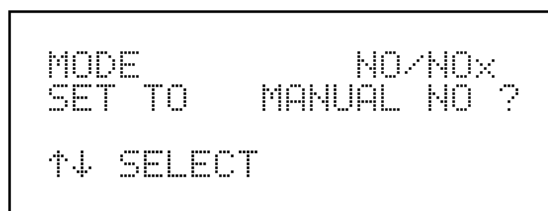
If option switch 7 (NO$_x$ Mode) is on, this screen is not displayed.

To display the Auto/Manual Mode screen:

> ➢ From the Main Menu choose Instrument Controls
> ➢ From the Instrument Controls menu choose Auto/Manual Mode

To use the Auto/Manual Mode screen:

> ➢ Use the ↑ and ↓ pushbutton to scroll through modes
> ➢ Press **ENTER** to select mode
> ➢ Press **MENU** to return to the Instrument Controls menu
> ➢ Press **RUN** to return to the Run screen

```
MODE              NO/NOx
SET TO    MANUAL NO ?

↑↓ SELECT
```

Auto/Manual Mode Screen

Temperature Compensation

Temperature compensation provides compensation for any changes to the instrument's output signal due to internal instrument temperature variations. The effects of internal instrument temperature changes on the analyzer's subsystems and output have been empirically determined. This empirical data is used to compensate for any changes in temperature. This compensation can be used for special applications, or when operating the instrument outside the recommended temperature range, even though the Model 42C does not require temperature compensation for EPA equivalency.

The temperature compensation screen is shown below. When temperature compensation is on, the first line of the display shows the current internal instrument temperature (measured by a thermistor on the Motherboard). When temperature compensation is off, the first line of the display shows the factory standard temperature of 30°C.

To display the Temperature Compensation screen:

➢ From the Main Menu choose Instrument Controls
➢ From the Instrument Controls menu choose Temperature Compensation

To use the Temperature Compensation screen:

➢ Press **ENTER** to toggle temperature compensation on and off
➢ Press **MENU** to return to the Instrument Controls menu
➢ Press **RUN** to return to the Run screen

```
TEMPERATURE     30.0°C
COMPENSATION       OFF

TURN               ON?
```

Temperature Compensation Screen

Pressure Compensation
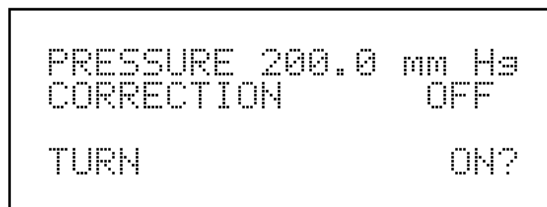
Pressure compensation provides compensation for any changes to the instrument's output signal due to reaction chamber pressure variations. The effects of reaction chamber pressure changes on the analyzer's subsystems and output have been empirically determined. This empirical data is used to compensate for any change in reaction chamber pressure. This compensation can be used even though the Model 42C does not require pressure compensation for EPA equivalency. The pressure compensation screen is shown below. When pressure compensation is on, the first line of the display represents the current pressure in the reaction chamber. When pressure compensation is off, the first line of the display shows the factory standard pressure of 200 mm Hg.

To display the Pressure Compensation screen:

> ➢ From the Main Menu choose Instrument Controls
> ➢ From the Instrument Controls menu choose Pressure Compensation

To use the Pressure Compensation screen:

> ➢ Press **ENTER** to toggle pressure compensation on and off
> ➢ Press **MENU** to return to the Instrument Controls menu
> ➢ Press **RUN** to return to the Run screen

```
PRESSURE 200.0 mm Hg
CORRECTION       OFF

TURN             ON?
```

Pressure Compensation Screen

Baud Rate

The Baud Rate screen, shown below, is used to set the RS-232 interface baud rate. Baud rates of 1200, 2400, 4800, and 9600 are available.

To display the Baud Rate screen:

> ➢ From the Main Menu choose Instrument Controls
> ➢ From the Instrument Controls menu choose Baud Rate

To use the Baud Rate screen:

> ➢ Use the ↑ and ↓ pushbuttons to increment/decrement the baud rate
> ➢ Press **ENTER** to accept a change
> ➢ Press **MENU** to return to the Instrument Controls menu
> ➢ Press **RUN** to return to the Run screen

```
BAUD RATE       1200
                2400?


↑↓ INC/DEC
```
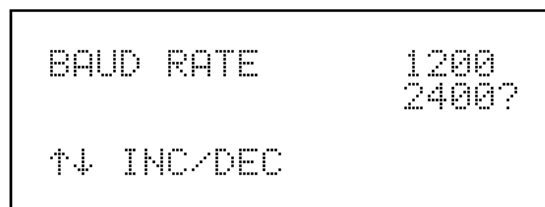
Baud Rate Screen

Instrument ID
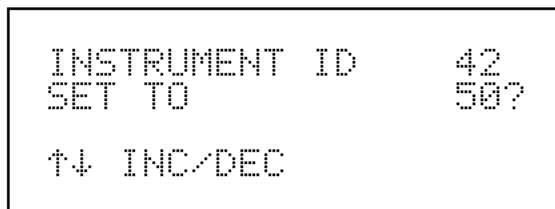
The Instrument ID screen, shown below, enables the Instrument ID to be user-defined. This is useful if two or more of the same instrument are connected to one computer. Valid Instrument ID numbers are from 0 to 99. The Model 42C has a default Instrument ID of 42. For more information about the Instrument ID, see Appendix B, "RS-232 Commands."

To display the Instrument ID screen:

> ➢ From the Main Menu choose Instrument Controls
> ➢ From the Instrument Controls menu choose Instrument ID

To use the Instrument ID screen:

> ➢ Use the ↑ and ↓ pushbuttons to increment/decrement the ID number
> ➢ Press **ENTER** to accept a change
> ➢ Press **MENU** to return to the Instrument Controls menu
> ➢ Press **RUN** to return to the Run screen

```
INSTRUMENT ID    42
SET TO           50?

↑↓ INC/DEC
```

Instrument ID Screen

Screen Brightness

The Screen Brightness screen, shown below, is used to change the screen brightness. Intensities of 25%, 50%, 75%, and 100% are available. Changing the screen brightness to a lower intensity will extend the life of the display.

To display the Screen Brightness screen:

> ➢ From the Main Menu choose Instrument Controls
> ➢ From the Instrument Controls menu choose Screen Brightness

To use the Screen Brightness screen:

> ➢ Use the ↑ and ↓ pushbuttons to increment/decrement the screen brightness
> ➢ Press **ENTER** to accept a change
> ➢ Press **MENU** to return to the Instrument Controls menu
> ➢ Press **RUN** to return to the Run screen

```
BRIGHTNESS     100 %
SET TO          25 %?

↑↓  INC/DEC
```
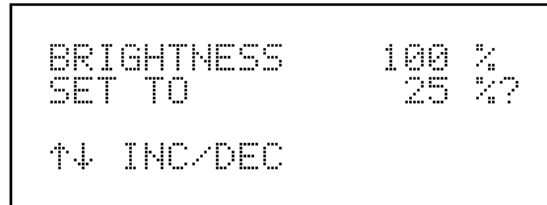
Screen Brightness Screen

Service Mode

The Service Mode screen, shown below, is used to turn the service mode on and off. The service mode includes parameters and functions that are useful when making adjustments or diagnosing the Model 42C. Meaningful data should not be collected when the instrument is in the service mode. For more information about the service mode, see "Service Mode Menu," later in this chapter.

To display the Service Mode screen:

> ➢ From the Main Menu choose Instrument Controls
> ➢ From the Instrument Controls menu choose Service Mode

To use the Service Mode screen:

> ➢ Press **ENTER** to toggle service mode on and off
> ➢ Press **MENU** to return to the Instrument Controls menu
> ➢ Press **RUN** to return to the Run screen

```
┌─────────────────────────────┐
│                             │
│   SERVICE MODE     OFF      │
│                             │
│   TURN             ON?      │
│                             │
└─────────────────────────────┘
```

Service Mode Screen

Time
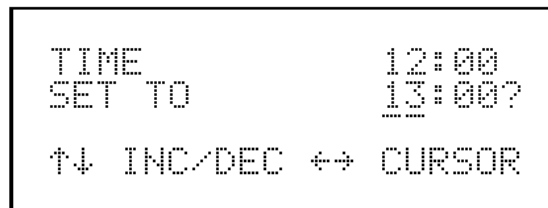
The internal clock is set by the Time screen as shown below. The first line of the display shows the current time (military). The second line of the display is used to change the time. The internal clock is powered by its own battery when instrument power is off.

To display the Time screen:

   ➢ From the Main Menu choose Instrument Controls
   ➢ From the Instrument Controls menu choose Time

To use the Time screen:

   ➢ Use the ↑ and ↓ pushbuttons to increment/decrement the hours and minutes
   ➢ Use the ← and → pushbuttons to move the cursor left and right
   ➢ Press **ENTER** to accept a change
   ➢ Press **MENU** to return to the Instrument Controls menu
   ➢ Press **RUN** to return to the Run screen

```
 ┌──────────────────────────────┐
 │ TIME            12:00        │
 │ SET TO          13:00?       │
 │                              │
 │ ↑↓ INC/DEC  ←→ CURSOR        │
 └──────────────────────────────┘
```

Time Screen

Date
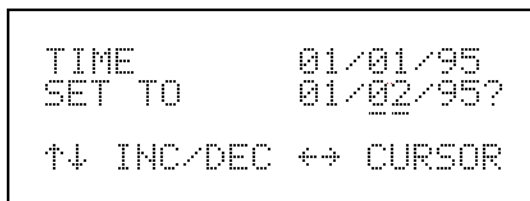
The date is set by the Date screen as shown below. The first line of the display shows the current date. The second line of the display is used to change the date. The date is updated by the internal clock.

To display the Date screen:

> ➢ From the Main Menu choose Instrument Controls
> ➢ From the Instrument Controls menu choose Date

To use the Date screen:

> ➢ Use the ↑ and ↓ pushbuttons to increment/decrement the month, day, and year
> ➢ Use the ← and → pushbutton to move the cursor left and right
> ➢ Press **ENTER** to accept a change
> ➢ Press **MENU** to return to the Instrument Controls menu
> ➢ Press **RUN** to return to the Run screen

```
TIME        01/01/95
SET TO      01/02/95?

↑↓ INC/DEC ←→ CURSOR
```

Date Screen

DIAGNOSTICS MENU

The Diagnostics menu, shown below, provides access to diagnostic information and functions. This menu is useful when troubleshooting the instrument.

To display the Diagnostics menu:

➢ From the Main Menu choose Diagnostics

To use the Diagnostics menu:

➢ Use the ↑ and ↓ pushbuttons move the cursor up and down
➢ Press **ENTER** to select a choice
➢ Press **MENU** to return to the Main Menu
➢ Press **RUN** to return to the Run screen

```
DIAGNOSTICS:
>PROGRAM NUMBER
 VOLTAGES
 TEMPERATURES
```

```
 PRESSURE
 FLOW
 TEST ANALOG OUTPUTS
 OPTION SWITCHES
```

Diagnostics Menu

Program Number
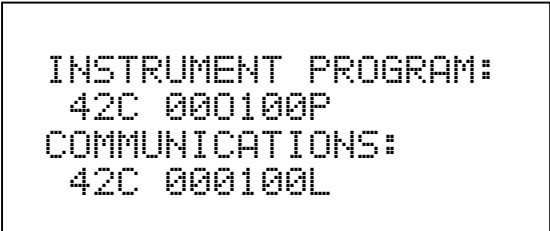
The Program Number screen, shown below, shows the version numbers of the programs installed. Prior to contacting the factory with any questions regarding the instrument, please note the program numbers.

To display the Program Number screen:

- ➢ From the Main Menu choose Diagnostics
- ➢ From the Diagnostics menu choose Program Number

To use the Program Number screen:

- ➢ This is a view only screen
- ➢ Press **MENU** to return to the Diagnostics menu
- ➢ Press **RUN** to return to the Run screen

```
INSTRUMENT PROGRAM:
 42C 000100P
COMMUNICATIONS:
 42C 000100L
```

Program Number Screen

Voltages

The Voltages screen as shown below, displays the dc power supply voltages. This screen enables the power supply to be quickly tested for low or fluctuating voltages without having to use a voltage meter.

To display the Voltages screen:

> ➢ From the Main Menu choose Diagnostics
> ➢ From the Diagnostics menu choose Voltages

To use the Voltages screen:

> ➢ This is a view only screen
> ➢ Press **MENU** to return to the Diagnostics menu
> ➢ Press **RUN** to return to the Run screen

```
VOLTAGES:
>PMT           -710.0 V
  +5 SUPPLY      4.9 V
 +15 SUPPLY     15.1 V
```

```
 -15 SUPPLY   -15.2 V
 BATTERY        2.9 V
```

Voltages Screen

Temperatures

The Temperatures screen, as shown below, displays the internal temperature, reaction chamber temperature, converter temperature, and cooler temperature.

To display the Temperatures screen:

> ➢ From the Main Menu choose Diagnostics
> ➢ From the Diagnostics menu choose Temperatures

To use the Temperatures screen:

> ➢ This is a view only screen
> ➢ Use the ↑ and ↓ pushbutton to move the cursor up and down
> ➢ Press **MENU** to return to the Diagnostics menu
> ➢ Press **RUN** to return to the Run screen

```
TEMPERATURES:
>INTERNAL    30.0 °C
 CHAMBER     49.2 °C
 COOLER      -2.6 °C


 CONVERTER  325.  °C
 CONV SET   325.  °C
```

Temperatures Screen

Pressure

The Pressure screen, shown below, displays the reaction chamber pressure. The pressure is measured by a pressure transducer in-line with the reaction chamber.

To display the Pressure screen:

- ➢ From the Main Menu choose Diagnostics
- ➢ From the Diagnostics menu choose Pressure

To use the Pressure screen:

- ➢ This is a view only screen
- ➢ Press **MENU** to return to the Diagnostics menu
- ➢ Press **RUN** to return to the Run screen

```
PRESSURE 192.8 mm Hg
```
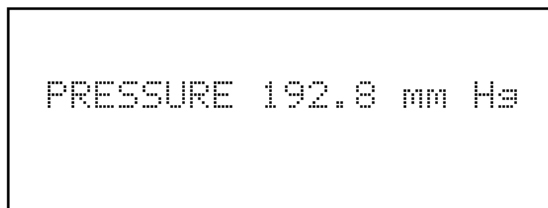
Pressure Screen

Flow

The Flow screen, shown below, displays the sample and ozonator flow rate. The flows are measured by internal flow sensors. For more information, refer to Chapter 1, "Operations."

To display the Flow screen:

> ➢ From the Main Menu choose Diagnostics
> ➢ From the Diagnostics menu choose Flow

To use the Flow screen:

> ➢ This is a view only screen
> ➢ Press **MENU** to return to the Diagnostics menu
> ➢ Press **RUN** to return to the Run screen

```
FLOW:
SAMPLE          0.500 LPM

OZONATOR              OK
```

Flow Screen

Test Analog Outputs
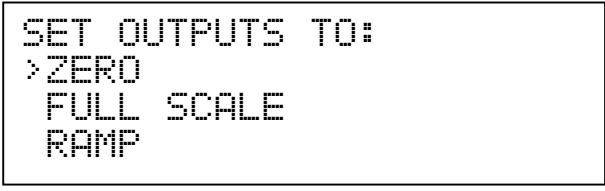
The Test Analog Outputs menu contains three choices: Zero, Full-scale, and Ramp, as shown below. Zero sets the analog outputs to 0 volts, Full-scale sets the analog outputs to the full-scale voltage, and Ramp generates a digital to analog (DAC) ramp that fully tests the analog outputs.

To display the Test Analog Outputs menu:

> ➢ From the Main Menu choose Diagnostics
> ➢ From the Diagnostics menu choose Test Analog Outputs

To use the Test Analog Output menu:

> ➢ Use the ↑ and ↓ pushbuttons to move the cursor up and down
> ➢ Press **ENTER** to select a choice
> ➢ Press **MENU** to return to the Diagnostics menu
> ➢ Press **RUN** to return to the Run screen

```
SET OUTPUTS TO:
>ZERO
 FULL SCALE
 RAMP
```

Test Analog Outputs Menu

Zero. The Zero screen, as shown below, sets the analog outputs to 0 volts. Use the ↑ and ↓ pushbuttons to increment/decrement the output level. For example, to set the analog outputs to 5% of full-scale, use the ↑ pushbutton to increment the 0.0 to 5.0%.

To display the Zero screen:

> ➢ From the Main Menu choose Diagnostics
> ➢ From the Diagnostics menu choose Test Analog Outputs
> ➢ From the Set Outputs menu choose Zero

To use the Zero screen:

> ➢ Use the ↑ and ↓ pushbuttons to increment/decrement the output level
> ➢ Press **MENU** to return to the Set Outputs menu and cancel the zero output
> ➢ Press **RUN** to return to the Run screen and cancel the zero output

```
OUTPUTS        0.0 %

↑↓ INC/DEC
```
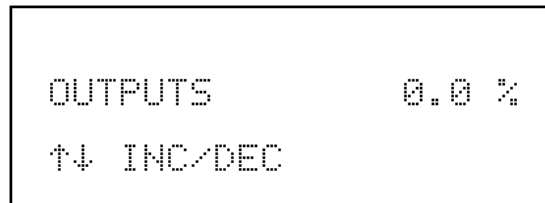
Zero Analog Outputs Screen
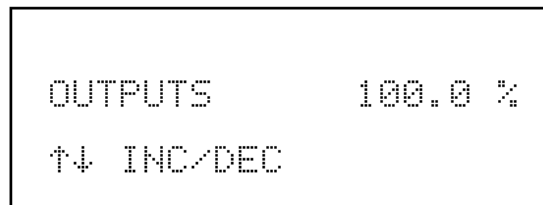
Full-scale. The Full-scale screen, as shown below, sets the analog outputs to full-scale. Use the ↑ and ↓ pushbuttons to increment/decrement the output level. For example, to set the analog outputs to 95% of full-scale, use the ↓ pushbutton to decrement the 100.0 to 95.0%.

To display the Full-scale screen:

> ➢ From the Main Menu choose Diagnostics
> ➢ From the Diagnostics menu choose Test Analog Outputs
> ➢ From the Set Outputs menu choose Full-scale

To use the Full-scale screen:

> ➢ Use the ↑ and ↓ pushbuttons to increment/decrement the output level
> ➢ Press **MENU** to return to the Set Outputs menu and cancel the full-scale output
> ➢ Press **RUN** to return to the Run screen and cancel the full-scale output

```
OUTPUTS        100.0 %

↑↓ INC/DEC
```

Full-scale Analog Outputs Screen

Ramp. The digital to analog (DAC) ramp is used to fully test the analog outputs. The analog outputs start at -2.3% and then increments by 0.1% every second until it reaches 100.0%. A linear output indicates that the analog outputs are operating correctly.

To display the Ramp screen:

> ➢ From the Main Menu choose Diagnostics
> ➢ From the Diagnostics menu choose Test Analog Outputs
> ➢ From the Set Outputs menu choose Ramp

To use the Ramp screen:

> ➢ This is a view only screen
> ➢ Press **MENU** to return to the Set Outputs menu and cancel the ramp output
> ➢ Press **RUN** to return to the Run screen and cancel the ramp output

```
OUTPUTS        -2.3 %


```
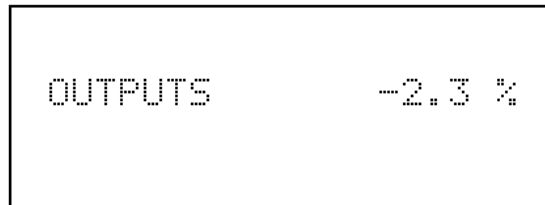
Ramp Analog Outputs Screen

Option Switches

The Option Switches screen, shown below, enables the settings of the internal option switches to be viewed. Option switch settings cannot be changed through the software. For more information about the internal option switches, see "Internal Option Switches" later in this chapter.

To display the Option Switches screen:

> ➢ From the Main Menu choose **Diagnostics**
> ➢ From the Diagnostics menu **choose** Option Switches

To use the Option Switches screen:

> ➢ This is a view only screen
> ➢ Use the ↑ and ↓ pushbuttons to move the cursor up and down
> ➢ Press **MENU** to return to the Diagnostics menu
> ➢ Press **RUN** to return to the Run screen

```
OPTION SWITCHES:
>#1 REMOTE              ON
 #2 RS-232              ON
 #3 Z/SPAN VALVE       OFF
```

```
 #4 DUAL RANGE         OFF
 #5 AUTORANGE          OFF
 #6 LOCK               OFF
 #7 EXT RANGES         OFF
 #8 NOx MODE           OFF
```

Option Switch Status Screen

ALARMS MENU

The Alarms menu, shown below, displays a list of items that are monitored by the analyzer. If the item being monitored goes outside the lower or upper limit, the status of that item will go from OK to either LOW or HIGH, respectively. The number in the upper right-hand corner of the display indicates how many alarms have occurred. If no alarms are detected, the number zero is displayed.

To see the actual reading of an item and its minimum and maximum limits, move the cursor to the item and press **ENTER**.

To display the Alarms menu:

➢ From the Main Menu choose Alarm

To use the Alarms menu:

➢ Use the ↑ and ↓ pushbuttons to move the cursor up and down
➢ Press **ENTER** to select a choice
➢ Press **MENU** to return to the Main Menu
➢ Press **RUN** to return to the Run screen

```
ALARMS DETECTED:    0
>INTERNAL TEMP     OK
 CHAMBER TEMP      OK
 COOLER TEMP       OK
```

```
 CONV.TEMP         OK
 PRESSURE          OK
 SAMPLE FLOW       OK
 OZONATOR FLOW     OK
 NO  CONC          OK
 NO2 CONC          OK
 NOx CONC          OK
```

Alarm Menu

Internal Temperature
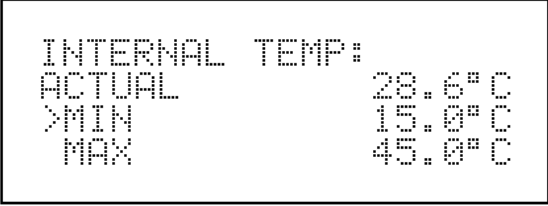
The Internal Temperature screen, shown below, displays the current internal temperature and the factory-set min and max alarm limits. The min and max alarm limits can be changed when the instrument is in the service mode. Acceptable alarm limits range from 8 to 47oC. If the internal temperature reading goes beyond either the min or max alarm limit, an alarm is activated. The word alarm appears in the Run screen and in the Main Menu.

To display the Internal Temperature screen:

> ➢ From the Main Menu choose Alarm
> ➢ From the Alarm menu choose Internal Temperature

To use the Internal Temperature screen:

> ➢ Use the ↑ and ↓ pushbuttons to move up and down (service mode on)
> ➢ Press **ENTER** to select a choice (service mode on)
> ➢ Press **MENU** to return to the Alarm menu
> ➢ Press **RUN** to return to the Run screen

```
INTERNAL  TEMP:
ACTUAL          28.6°C
>MIN            15.0°C
 MAX            45.0°C
```

Internal Temperature Screen
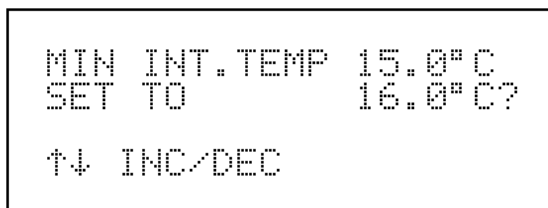
Min and Max Internal Temperature Limit: The Min Internal Temperature alarm limit screen, shown below, is accessible only when the instrument is in the service mode. It is used to change the min internal temperature alarm limit. The min and max Internal Temperature screens function the same way.

To display the Min or Max Internal Temperature limit screen (service mode on):

- ➢ From the Main Menu choose Alarm
- ➢ From the Alarm menu choose Internal Temperature
- ➢ From the Internal Temperature menu choose Min or Max

To use the Min or Max Internal Temperature limit screen (service mode on):

- ➢ Use the ↑ and ↓ pushbuttons to increment/decrement the value
- ➢ Press **ENTER** to accept the change
- ➢ Press **MENU** to return to the Internal Temperature menu
- ➢ Press **RUN** to return to the Run screen

```
MIN INT.TEMP 15.0°C
SET TO       16.0°C?

↑↓ INC/DEC
```

Set Min Internal Temperature Screen

Chamber Temperature

The Chamber Temperature screen, shown below, displays the current chamber temperature and the factory-set min and max alarm limits. The min and max alarm limits can be changed when the instrument is in the service mode. Acceptable alarm limits range from 47 to 51°C. If the chamber reading goes beyond either the min or max limit, an alarm is activated. The word alarm appears in the Run screen and in the Main Menu.

To display the Chamber Temperature screen:

> ➤ From the Main Menu choose Alarm
> ➤ From the Alarm menu choose Chamber Temperature

To use the Chamber Temperature screen:

> ➤ Use the ↑ and ↓ pushbuttons to move up and down (service mode on)
> ➤ Press **ENTER** to select a choice (service mode on)
> ➤ Press **MENU** to return to the Alarm menu
> ➤ Press **RUN** to return to the Run screen

```
CHAMBER TEMP:
ACTUAL          49.4°C
>MIN            47.0°C
 MAX            51.0°C
```

Chamber Temperature Screen
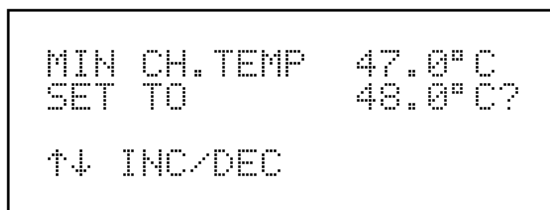
Min and Max Chamber Temperature Limits: The Min Chamber Temperature alarm limit screen, shown below, is accessible only when the instrument is in the service mode. It is used to change the min chamber temperature alarm limit. The min and max Chamber Temperature screens function the same way.

To display the Min or Max Chamber Temperature limit screen (service mode on):

- ➢ From the Main Menu choose Alarm
- ➢ From the Alarm menu choose Chamber Temperature
- ➢ From the Chamber Temperature menu choose Min or Max

To use the Min or Max Chamber Temperature limit screen (service mode on):

- ➢ Use the ↑ and ↓ pushbuttons to increment/decrement the value
- ➢ Press **ENTER** to accept the change
- ➢ Press **MENU** to return to the Chamber Temperature menu
- ➢ Press **RUN** to return to the Run screen

```
MIN CH.TEMP   47.0°C
SET TO        48.0°C?

↑↓ INC/DEC
```

Set Minimum Chamber Temperature Screen

Cooler Temperature

The Cooler Temperature screen, shown below, displays the current cooler temperature and the factory-set min and max alarm limits. The min and max alarm limits can be changed when the instrument is in the service mode. Acceptable alarm limits range from -25 to -1°C. If the cooler temperature reading goes beyond either the min or max alarm limit, an alarm is activated. The word alarm appears in the Run screen and in the Main Menu.

To display the Cooler Temperature screen:

> ➢ From the Main Menu choose Alarm
> ➢ From the Alarm menu choose Cooler Temperature

To use the Cooler Temperature screen:

> ➢ Use the ↑ and ↓ pushbuttons to move up and down (service mode on)
> ➢ Press **ENTER** to select a choice (service mode on)
> ➢ Press **MENU** to return to the Alarm menu
> ➢ Press **RUN** to return to the Run screen

```
COOLER TEMP:
ACTUAL        -2.8°C
>MIN          -5.0°C
 MAX          -1.0°C
```

Cooler Temperature Screen

Min and Max Cooler Temperature Limits: The Min Cooler Temperature alarm limit screen, shown below, is accessible only when the instrument is the service mode. It is used to change the min cooler temperature alarm limit. The min and max cooler temperature screens function the same way.

To display the Min or Max Cooler Temperature limit screen (service mode on):

> ➢ From the Main Menu choose Alarm
> ➢ From the Alarm menu choose Cooler Temperature
> ➢ From the Cooler Temperature menu choose Min or Max

To use the Min or Max Cooler Temperature limit screen (service mode on):

> ➢ Use the ↑ and ↓ pushbuttons to increment/decrement the value
> ➢ Press **ENTER** to accept the change
> ➢ Press **MENU** to return to the Cooler Temperature menu
> ➢ Press **RUN** to return to the Run screen

```
MIN CLR.TEMP -5.0°C
SET TO       -4.0°C?

↑↓ INC/DEC
```

Set Min Cooler Temperature Screen

Converter Temperature
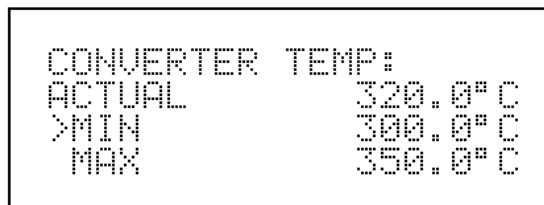
The Converter Temperature screen, shown below, displays the current converter temperature and the factory-set min and max alarm limits. The min and max alarm limits can be changed when the instrument is in the service mode. Acceptable alarm limits range from 300 to 375°C. If the converter temperature reading goes beyond either the min or max alarm limit, an alarm is activated. The word alarm appears in the Run screen and in the Main Menu.

To display the Converter Temperature screen:

> ➢ From the Main Menu choose Alarm
> ➢ From the Alarm menu choose Converter Temperature

To use the Converter Temperature screen:

> ➢ Use the ↑ and ↓ pushbuttons to move up and down (service mode on)
> ➢ Press **ENTER** to select a choice (service mode on)
> ➢ Press **MENU** to return to the Alarm menu
> ➢ Press **RUN** to return to the Run screen

```
CONVERTER TEMP:
ACTUAL        320.0° C
>MIN          300.0° C
 MAX          350.0° C
```

Converter Temperature Screen
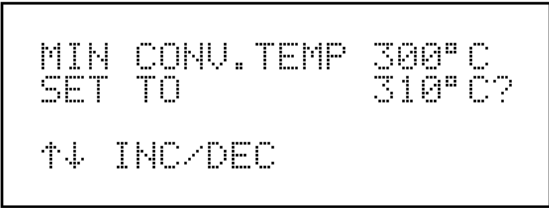
Min and Max Converter Temperature Limits: The Min Converter Temperature alarm limit screen, shown below, is accessible only when the instrument is in the service mode. It is used to change the min converter temperature alarm limit. The min and max Converter Temperature screens function the same way. Please note, the ozonator will not turn on if the converter is below alarm limit.

To display the Min or Max Converter Temperature limit screen (service mode on):

> ➢ From the Main Menu choose Alarm
> ➢ From the Alarm menu choose Converter Temperature
> ➢ From the Converter Temperature menu choose Min or Max

To use the Min or Max Converter Temperature limit screen (service mode on):

> ➢ Use the ↑ and ↓ pushbuttons to increment/decrement the value
> ➢ Press **ENTER** to accept the change
> ➢ Press **MENU** to return to the Converter Temperature menu
> ➢ Press **RUN** to return to the Run screen

```
MIN CONV.TEMP 300°C
SET TO        310°C?

↑↓ INC/DEC
```

Set Min Converter Temperature Screen
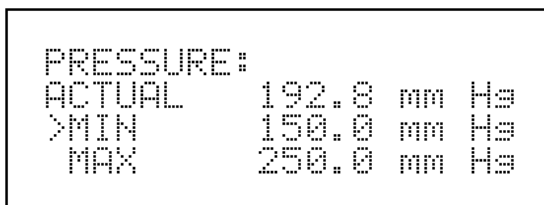
Pressure

The Pressure screen, shown below, displays the current reaction chamber pressure reading and the factory-set min and max alarm limits. The min and max alarm limits can be changed when the instrument is in the service mode. Acceptable alarm limits range from 50 to 300 mm Hg. If the pressure reading goes beyond either the min or max alarm limit, an alarm is activated. The word alarm appears in the Run screen and in the Main Menu.

To display the Pressure screen:

➢ From the Main Menu choose Alarm
➢ From the Alarm menu choose Pressure

To use the Pressure screen:

➢ Use the ↑ and ↓ pushbuttons to move up and down (service mode on)
➢ Press **ENTER** to select a choice (service mode on)
➢ Press **MENU** to return to the Alarm menu
➢ Press **RUN** to return to the Run screen

```
PRESSURE:
ACTUAL    192.8 mm Hg
>MIN      150.0 mm Hg
 MAX      250.0 mm Hg
```

Pressure Screen
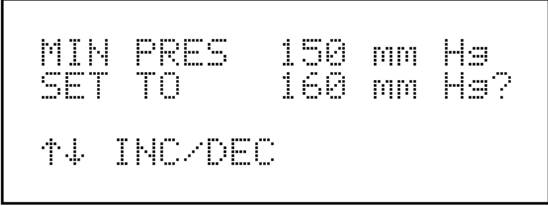
Min and Max Pressure Limits: The Min Pressure limit screen, shown below, is accessible only when the instrument is in the service mode. It is used to change the min pressure alarm limit. The min and max Pressure screens function the same way.

To display the Min or Max Pressure limit screen (service mode on):

> ➢ From the Main Menu choose Alarm
> ➢ From the Alarm menu choose Pressure
> ➢ From the Pressure menu choose Min or Max

To use the Min or Max Pressure limit screen (service mode on):

> ➢ Use the ↑ and ↓ pushbuttons to increment/decrement the value
> ➢ Press **ENTER** to accept the change
> ➢ Press **MENU** to return to the Pressure menu
> ➢ Press **RUN** to return to the Run screen

```
┌─────────────────────────────────────┐
│                                      │
│  MIN PRES   150 mm Hg                │
│  SET TO     160 mm Hg?               │
│                                      │
│  ↑↓ INC/DEC                          │
│                                      │
└─────────────────────────────────────┘
```

Set Min Pressure Screen

Sample Flow
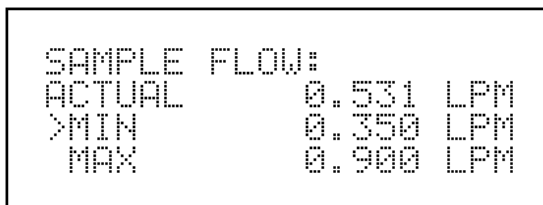
The Sample flow screen, shown below, displays the current sample flow reading and the factory-set min and max alarm limits. The min and max alarm limits can be changed when the instrument is in the service mode. Acceptable alarm limits range from 0 to 1 LPM. If the sample flow reading goes beyond either the min or max alarm limit, an alarm is activated. The word alarm appears in the Run screen and in the Main Menu.

To display the Sample Flow screen:

> ➢ From the Main Menu choose Alarm
> ➢ From the Alarm menu choose Sample Flow

To use the Sample Flow screen:

> ➢ Use the ↑ and ↓ pushbuttons to move up and down (service mode on)
> ➢ Press **ENTER** to select a choice (service mode on)
> ➢ Press **MENU** to return to the Alarm menu
> ➢ Press **RUN** to return to the Run screen

```
SAMPLE FLOW:
ACTUAL      0.531 LPM
>MIN        0.350 LPM
 MAX        0.900 LPM
```

Sample Flow Screen
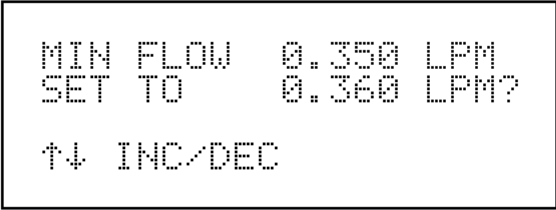
Min and Max Sample Flow Limits: The Min Sample Flow limit screen, shown below, is accessible only when the instrument is in the service mode. It is used to change the min sample flow alarm limit. The min and max Sample Flow screens function the same way.

To display the Min or Max Sample Flow limit screen (service mode on):

> ➢ From the Main Menu choose Alarm
> ➢ From the Alarm menu choose Sample Flow
> ➢ From the Sample Flow menu choose Min or Max

To use the Min or Max Sample Flow limit screen (service mode on):

> ➢ Use the ↑ and ↓ pushbuttons to increment/decrement the value
> ➢ Press **ENTER** to accept the change
> ➢ Press **MENU** to return to the Sample Flow menu
> ➢ Press **RUN** to return to the Run screen

```
┌────────────────────────────────┐
│                                │
│  MIN FLOW  0.350 LPM           │
│  SET TO    0.360 LPM?          │
│                                │
│  ↑↓ INC/DEC                    │
│                                │
└────────────────────────────────┘
```

Set Min Sample Flow Screen

Ozonator Flow Alarm

If the ozonator flow reading is 0.050 LPM (50 cc) or below, an alarm is activated, and an alarm condition screen, shown below, appears. If the ozonator flow is above 0.050 LPM, the no alarm condition screen shown below is displayed, indicating that the flow is acceptable. Inadequate ozonator flow will cause the ozonator to overheat, resulting in permanent damage to the ozonator.

To display the Ozonator Flow screen:

> ➢ From the Main Menu choose Alarm
> ➢ From the Alarm menu choose Ozonator Flow

To use the Ozonator Flow screen:

> ➢ These screens are view only
> ➢ Press **MENU** to return to the Alarm menu
> ➢ Press **RUN** to return to the Run screen

```
OZONATOR FLOW:
ACTUAL           LOW
```

Ozonator Flow Screen (Alarm Condition)

```
OZONATOR FLOW:
ACTUAL   >0.050 LPM
```

Ozonator Flow Screen (No Alarm Condition)

NO, NO$_2$, and NO$_x$ Concentration
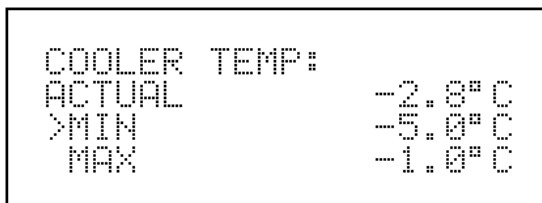
The NO Concentration screen, shown below, displays the current NO concentration and the factory-set min and max alarm limits. The min and max alarm limits can be changed when the instrument is in the service mode. Acceptable alarm limits range from 0 to 100,000 ppb. If the NO concentration reading goes beyond either the min or max alarm limit, an alarm is activated. The word alarm appears in the Run screen and in the Main Menu. If the min alarm limit is set to zero, no alarm will be activated. The NO$_2$ and NO$_x$ Concentration screens function the same way.

To display the NO, NO$_2$, or NO$_x$ screen:

> ➢ From the Main Menu choose Alarm
> ➢ From the Alarm menu choose NO Conc, NO$_2$ Conc, or NO$_x$ Conc

To use the NO Conc, NO$_2$ Conc, or NO$_x$ Conc screen:

> ➢ Use the ↑ and ↓ pushbuttons to move up and down (service mode on)
> ➢ Press **ENTER** to select a choice (service mode on)
> ➢ Press **MENU** to return to the Alarm menu
> ➢ Press **RUN** to return to the Run screen

```
NO CONCENTRATION:
ACTUAL PPB      62.7
>MIN             0.0
 MAX          100000
```

NO Concentration screen
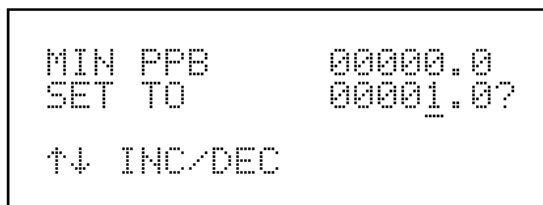
Max NO, NO₂, and NOₓ Concentration Limits: The NO, NO2, and NOx min and max concentration limit screens are accessible only when the instrument is in the service mode. They are used to change the min and max concentration alarm limits. The min NO concentration screen is shown below.

To display the Min or Max NO, NO₂, or NOₓ Conc limit screen (service mode on):

- ➢ From the Main Menu choose Alarm
- ➢ From the Alarm menu choose NO Conc, NO₂ Conc, or NOₓ Conc
- ➢ From the NO, NO₂, or NOₓ menu choose Min or Max

To use the Min or Max limit screens (service mode on):

- ➢ Use the ↑ and ↓ pushbuttons to increment/decrement the value
- ➢ Press **ENTER** to accept the change
- ➢ Press **MENU** to return to the NO, NO₂, or NOₓ menu
- ➢ Press **RUN** to return to the Run screen

```
┌─────────────────────────────────┐
│                                 │
│  MIN PPB      00000.0           │
│  SET TO       00001.0?          │
│                                 │
│  ↑↓ INC/DEC                     │
│                                 │
└─────────────────────────────────┘
```

Set Min NO Concentration Screen

SERVICE MODE MENU

The Service Mode menu, shown below, appears only when the instrument is in the service mode. To put the instrument into the service mode, select Instrument Controls from the Main Menu, then from the Instrument Controls menu select Service Mode. When the instrument is in the service mode, the Main Menu extends to include the Service Mode menu. The service mode includes some of the same information found in the Diagnostic menu. However, items such as PMT voltage supply, converter set temperature, pressure, sample flow, and ozonator flow readings are updated every second as opposed to every 10 seconds. The rapid update time enables the readings on the display to respond faster to adjustment. In addition, advanced diagnostic functions are included in the service mode. Meaningful data should not be collected when the instrument is in the service mode.

To display the Service Mode menu:

> ➢ From the Main Menu choose Service Mode

To use the Service Mode menu:

> ➢ Use the ↑ and ↓ pushbuttons to move the cursor up and down
> ➢ Press **ENTER** to select a choice
> ➢ Press **MENU** to return to the Main Menu
> ➢ Press **RUN** to return to the Run screen

```
SERVICE MODE:
>PMT SUPPLY
 CONV SET TEMP
 PRESSURE
```

```
ZERO FREQUENCY
A/D FREQUENCY
RELAY LOGIC
OZONATOR SAFETY
SET TEST DISPLAY
```

Service Mode Menu

PMT Supply

The PMT Supply screen, shown below, shows the PMT supply voltage. The PMT supply voltage reading is updated every second. This screen is used while adjusting the PMT voltage. This adjustment should only be performed by an instrument service technician.

CAUTION: Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, "Servicing."

To display the PMT Supply screen:

> ➢ From the Main Menu choose Service Mode
> ➢ From the Service Mode menu choose PMT Supply

To use the PMT Supply screen:

> ➢ This is a view only screen
> ➢ Press **MENU** to return to the Service Mode menu
> ➢ Press **RUN** to return to the Run screen

```
PMT SUPPLY    -710 V
```

PMT Supply Screen

Converter Set Temperature

The Converter Set Temperature screen, shown below, shows the converter set temperature. The converter set temperature reading is updated every second. This screen is used while adjusting R1 (converter set temperature) on the Temperature Control Board. This adjustment should only be performed by an instrument service technician.

CAUTION: Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, "Servicing."

To display the Converter Set Temperature screen:

> ➢ From the Main Menu choose Service Mode
> ➢ From the Service Mode menu choose Converter Set Temperature

To use the Converter Set Temperature screen:

> ➢ This is a view only screen
> ➢ Press **MENU** to return to the Service Mode menu
> ➢ Press **RUN** to return to the Run screen

```
CONV SET TEMP  325°C
```

Converter Set Temperature Screen

Pressure

The Pressure screen, shown below, shows the reaction chamber pressure. The reaction chamber pressure is updated every second. This screen is used while adjusting the pressure transducer potentiometers. This adjustment should only be performed by an instrument service technician.

CAUTION: Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, "Servicing."

To display the Pressure screen:

> ➢ From the Main Menu choose Service Mode
> ➢ From the Service Mode menu choose Pressure

To use the Pressure screen:

> ➢ This is a view only screen
> ➢ Press **MENU** to return to the Service Mode menu
> ➢ Press **RUN** to return to the Run screen

```
PRESSURE 192.8 mm Hg
```

Pressure Screen

Sample Flow

The Sample Flow screen, shown below, shows the sample flow. The sample flow reading is updated every second. This screen is used while the sample flow sensor potentiometers are adjusted. The potentiometer closest to the divider panel is the zero adjust potentiometer and the potentiometer farthest from the divider panel is the span potentiometer. These adjustments should only be performed by an instrument service technician.
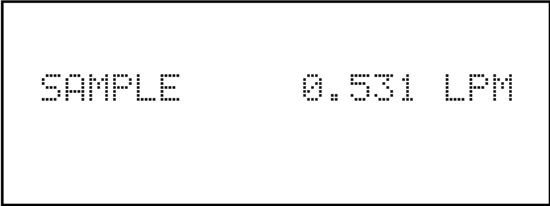
CAUTION: Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, "Servicing."

To display the Sample Flow screen:

  ➢ From the Main Menu choose Service Mode
  ➢ From the Service Mode menu choose Sample Flow

To use the Sample Flow screen:

  ➢ This is a view only screen
  ➢ Press **MENU** to return to the Service Mode menu
  ➢ Press **RUN** to return to the Run screen

```
SAMPLE     0.531 LPM
```

Sample Flow Screen

Zero Frequencies

The Zero Frequency menu, shown below, is used only if the Input Board has been repaired or replaced. The Z1 and Z2 Frequency screens are used to null any electronic offsets generated from the Input board. See "Z1 and Z2 Frequency Screens" below for more information. This adjustment should only be performed by an instrument service technician.

CAUTION: Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, "Servicing."

To display the Zero Frequencies menu:

  ➢ From the Main Menu choose Service Mode
  ➢ From the Service Mode menu choose Zero Frequencies

To use the Zero Frequencies menu:

  ➢ Use the ↑ and ↓ pushbuttons to move the cursor up and down
  ➢ Press **ENTER** to select a choice
  ➢ Press **MENU** to return to the Service Mode menu
  ➢ Press **RUN** to return to the Run screen

```
ADJUST Z2, Z1, Z2:
>Z2 FREQUENCY
 Z1 FREQUENCY
```

Zero Frequencies Menu

Z1 and Z2 Frequency Screens: The Z1 and Z2 Frequency screens are used to adjust the high and low gain stages of the Input Board to a baseline frequency of 3000 hertz. This is only necessary when the Input board has been recently repaired or replaced. These adjustments should only be performed by an instrument service technician.

CAUTION: Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, "Servicing."

Entry into either the Z1 or Z2 Frequency screens causes the PMT to be turned off, and consequently affects the analog outputs. Be sure to allow 15 to 30 minutes for the analyzer to warm. Adjust Z2 on the Input Board until a reading of 3000 hertz is displayed. Next, go to the Z1 Frequency screen and adjust Z1 on the Input Board until a reading of 3000 hertz is displayed. Since each adjustment affects the other, it may be necessary to repeat the procedure several times.

To display the Z1 and Z2 Frequency screens:

➢ From the Main Menu choose Service Mode
➢ From the Diagnostics menu choose Zero Frequencies
➢ From the Zero Frequencies menu choose Z1 or Z2 Frequency

To use the Z1 and Z2 Frequency screen:

➢ Adjust Z2 on the Input Board to set Z2 Frequency to 3000 Hz
➢ Adjust Z1 on the Input Board to set Z1 Frequency to 3000 Hz
➢ Press **MENU** to return to the Zero Frequencies menu
➢ Press **RUN** to return to the Run screen

```
Z2 FREQUENCY      5812

ADJUST TO         3000
```

Z2 Frequency Screen

A/D Frequency

The A/D Frequency screen, shown below, displays the frequency of each of the analog to digital (A/D) converters located on the A/D Board. Each A/D has a frequency range between 0 and 100,000 Hertz. This frequency range corresponds to a voltage range of 0 to -10 volts dc. See Appendix B, "Schematics" for the A/D Board schematic. The A/D converters are assigned as follows:

Table 3-3. A/D Converters

A/D Converter	Function
AN0	Sample Flow
AN1	Permeation Oven Temperature
AN2	Ozonator Flow
AN3	Permeation Gas Temperature
AN4	Cooler Temperature
AN5	Spare
AN6	Pressure
AN7	Reaction Chamber Temperature
AN8	Converter Temperature
AN9	Converter Set Temperature
AN10	PMT Voltage
AN11	Internal Temperature

To display the A/D Frequency screen:

➢ From the Main Menu choose Service Mode
➢ From the Service Mode menu choose A/D Frequency

To use the A/D Frequency screen:

➢ Use the ↑ and ↓ pushbuttons to increment/decrement the A to D number
➢ Press **MENU** to return to the Service Mode menu
➢ Press **RUN** to return to the Run screen


```
A TO D FREQ        0
A TO D NUMBER   NONE

↑↓ INC/DEC
```
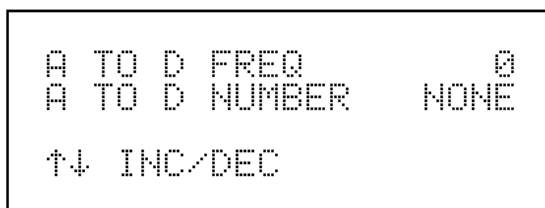
A/D Frequency Screen

Relay Logic
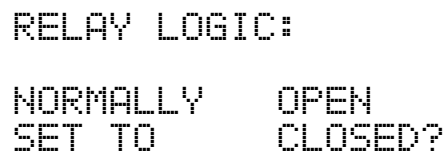
The Relay Logic screen, is shown below. The user sets the relays to be either normally open or closed.

To display the Relay Logic screen:

> ➢ From the Main Menu choose Service Mode
> ➢ From the Service Mode menu choose Relay Logic

To change the Relay Logic:

> ➢ Press **ENTER** to change the Logic
> ➢ Press **MENU** to return to the Service Mode menu
> ➢ Press **RUN** to return to the Run screen

```
RELAY LOGIC:

NORMALLY    OPEN
SET TO      CLOSED?
```

Relay Logic Screen

Ozonator Safety

As the ozone converter requires that the NOx converter be up to temperature in order to operate, the ozonator by default will not turn on until the NOx converter is above its minimum alarm temperature. If the user wishes, this feature can be overridden by setting the "Ozonator safety" condition to off. Regardless of the ozonator safety setting, the ozonator will not turn on if there is insufficient flow to the ozonator.

To display the Ozonator Safety screen:

> ➢ From the Main Menu choose Service Mode
> ➢ From the Service Mode menu choose Ozonator Safety

To change the Ozonator Safety:

> ➢ Press **ENTER** to change the Ozonator Safety status
> ➢ Press **MENU** to return to the Service Mode menu
> ➢ Press **RUN** to return to the Run screen

```
OZONATOR SAFETY    ON

SET TO             OFF?
```

Ozonator Safety Screen

Set Test Display
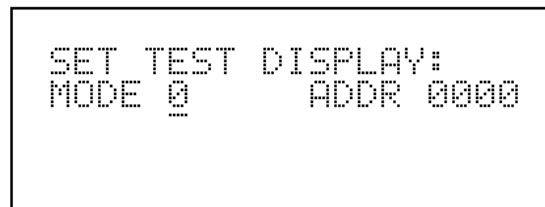
The Set Test Display screen, shown below, displays the contents of a given memory location. This screen is useful to TEI service personnel and should only be used when consulting with the factory.

To display the Set Test Display screen:

> ➢ From the Main Menu choose Service Mode
> ➢ From the Service Mode menu choose Set Test Display

To use the Set Test Display screen:

> ➢ Use the ↑ and ↓ pushbuttons to change the display mode
> ➢ Press **MENU** to return to the Service Mode menu
> ➢ Press **RUN** to return to the Run screen

```
SET TEST DISPLAY:
MODE 0      ADDR 0000
```

Set Test Display

INTERNAL OPTION SWITCHES

The internal option switches are located on the Motherboard (near the front panel), as shown in Figure 3-6 below. These switches are used to activate hardware and software options. Be sure to turn the instrument off and unplug the power cord before removing the instrument cover.

CAUTION: Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, "Servicing."
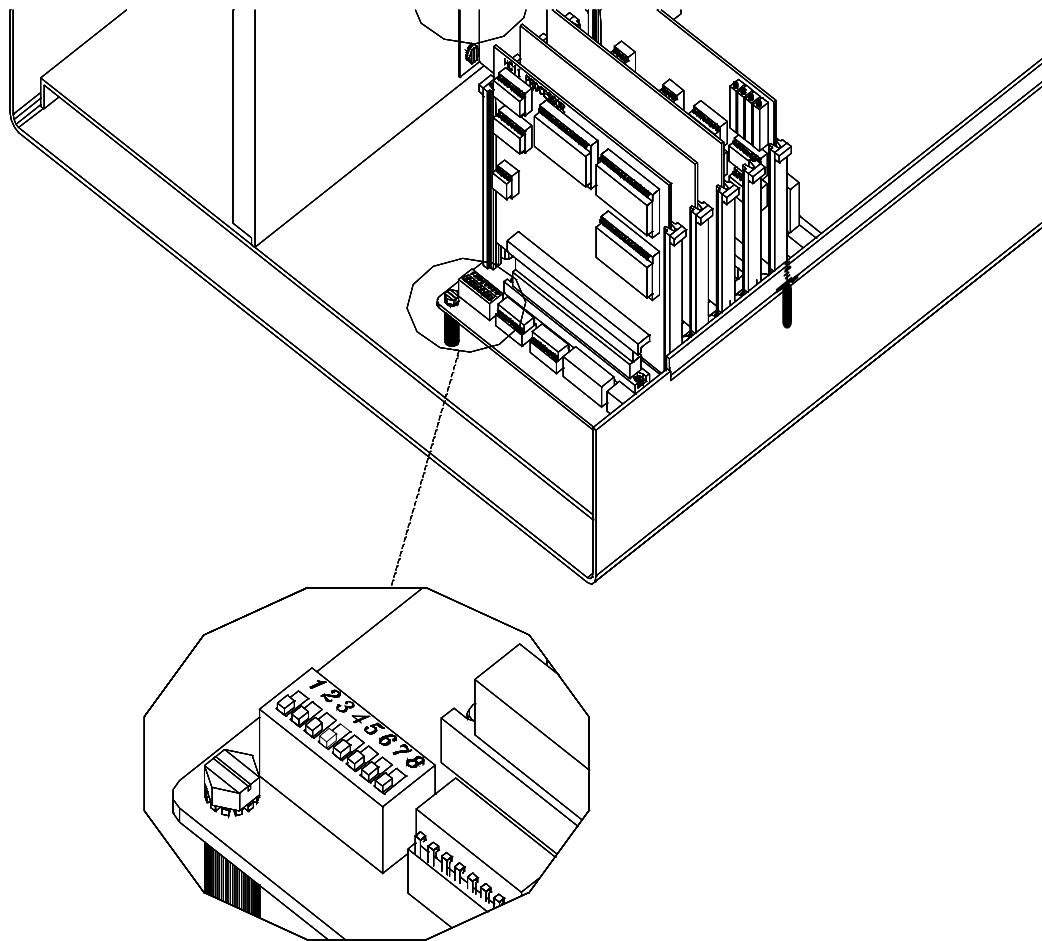
64P7192

Figure 3-6. Location of Internal Option Switches

Table 3-4. Option Switch Functions

Option Switch	Function
1	Remote
2	RS-232
3	Z/Span Valve
4	Dual Range
5	Autorange
6	Lock
7	Extended Ranges
8	NO_x Mode

Remote

Option switch 1 is on when a remote interface is installed, such as RS-232 or I/O activation.

RS-232

Option switch 2 is used to select between RS-232 and I/O activation. When option switch 2 is on, RS-232 is selected. When it is off, I/O activation is selected.

Zero/Span and Sample Solenoid Valves

Option switch 3 is on when the optional zero/span and sample solenoid valves are installed. For more information about the solenoid valves, see Chapter 9, "Optional Equipment."

Dual Range and Autorange

The dual range (option switch 4) and autorange (option switch 5) switches are used to activate the single, dual, and autorange modes. The following table shows how each mode is activated. For more information about the single, dual, and autorange modes, see "Operating Modes," earlier in this chapter.

Table 3-5. Operating Mode Truth Table

Operating Mode	Option Switch 4	Option Switch 5
Single Range Mode	Off	On or Off
Dual Range Mode	On	Off
Autorange Mode	On	On

Lock

When option switch 6 is on, instrument parameters are   locked   and can not be changed. This prevents any erroneous entry of instrument parameters. When option switch 6 is off, instrument parameters can be changed.

Extended Ranges

When this option switch is on, extended ranges are available. The extended ranges, in ppm mode, include: 0.2, 0.5, 1, 2, 5, 10, 20, 50, and 100 ppm. In the mg/m^3 mode, the extended ranges include: 0.5, 1, 2, 5, 10, 20, 50, 100, and 150 mg/m^3. When this option switch is off, the standard ranges are available. In the ppm mode, the standard ranges include: 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, and 20 ppm. In the mg/m^3, the standard ranges include: 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, and 30 mg/m^3. Whenever this option switched is changed, the PMT voltage must be readjusted. For more information about adjusting the PMT voltage, see Chapter 7, "Servicing."

NO$_x$ Mode

When this option switch is on, the instrument is the manual NO$_x$ mode. The manual NO$_x$ mode puts the mode solenoid valve into the closed position so that the sample gas passes through the NO$_2$-to-NO converter. Therefore, only the NO$_x$ concentration is determined. When this option switch is off, the instrument is in automatic (normal) mode.

CHAPTER 4
CALIBRATION

This chapter describes procedures for performing a multipoint calibration of the Model 42C. The information described here should be adequate to perform the calibration. However, if greater detail is desired, the user is referred to the Code of Federal Regulations, Title 40, Part 50, Appendix F.

The calibration technique is based on the rapid gas phase reaction between NO and O_3 which produces stoichiometric quantities of NO_2 in accordance with the reaction:

$$NO + O_3 \rightarrow NO_2 + O_2$$
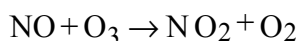
The quantitative nature of this reaction is such that when the NO concentration is known, the concentration of NO_2 can be determined. Ozone is added to excess NO in a dynamic calibration system, and the NO channel of the chemiluminescence $NO-NO_2-NO_x$ analyzer is used as an indicator of changes in NO concentration. Upon the addition of O_3, the decrease in NO concentration observed on the calibrated NO channel is equivalent to the concentration of NO_2 produced. The amount of NO_2 generated may be changed by adding variable amounts of O_3 from a stable O_3 generator. The following sections discuss the required apparatus and procedure for calibration of the Model 42C.

EQUIPMENT REQUIRED

Zero Gas Generator

A zero air source, free of contaminants such as NO, NO_2, and O_3 is required for dilution, calibration, and gas phase titration.

Compression. The zero air source should be at an elevated pressure to allow accurate and reproducible flow control and to aid in subsequent operations such as drying, oxidation, and scrubbing. An air compressor that gives an output of 10 psig is usually sufficient for most applications.

Drying. Several drying methods are available. Passing the compressed air through a bed of silica gel, using a heatless air dryer, or removing water vapor with a permeation dryer are three possible approaches.

Oxidation. NO is usually oxidized to NO_2 in order to ease its scrubbing. Oxidation can be accomplished by either ozonation or chemical contact. During ozonation, the air is passed through an ozone generator. The O_3 that is produced reacts with the NO to form NO_2. Care must be taken to allow sufficient residence time for the ozonation reaction to go to completion.

Chemical oxidation is accomplished by passing the air stream through a reacting bed. Such agents as CrO_3 on a alumina support or Purafil® are very efficient at oxidizing NO to NO_2. The chemical contact approach has the advantage of needing no electrical power input for its application.

Scrubbing. The last step in the generation of the zero air is the removal of the remaining contaminants by either further reaction or absorption. Fixed bed reactors are usually employed. The following materials have been shown to be effective:

Table 4-1. Scrubbing Materials

To Remove	Use
NO_2	Soda-Lime (6-12 mesh), Purafil®
Hydrocarbons	Molecular Sieve (4A), Activated Charcoal
O_3 and SO_2	Activated Charcoal

Gas Phase Titrator

Figure 4-1 shows the suggested placement of the component parts of a gas phase titration apparatus. All connections between components in the system should be made with glass, Teflon®, or other nonreactive material.

The air flow controllers should be devices capable of maintaining constant air flows within ±2 % of the required flow rate. The NO flow controller should be capable of maintaining constant NO flows within ±2 % of the required flow rate. Component parts in contact with the NO should be of a non-reactive material.

The pressure regulator for the standard NO cylinder must have a non-reactive diaphragm and internal parts and a suitable delivery pressure.
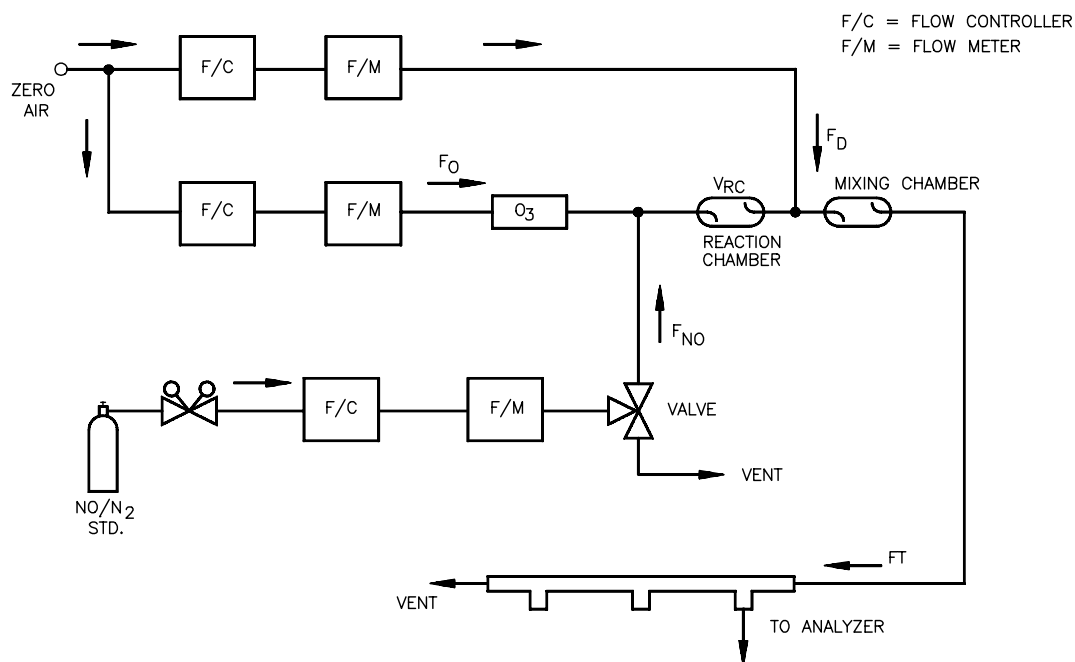
Figure 4-1. GPT System   64P808

The ozone generator must be capable of generating sufficient and stable levels of ozone for reaction with NO to generate NO_2 concentrations in the range required. Ozone generators of the electric discharge type may produce NO and NO_2 and are not recommended.

A valve used to divert the NO flow when zero air is required at the manifold may be used. The valve should be constructed of glass, Teflon, or other non-reactive material.

The reaction chamber used for the reaction of ozone with excess NO should be constructed of glass, Teflon, or other non-reactive material. The chamber should be of sufficient volume so that the residence time meets the requirements specified further in this chapter. The mixing chamber used to provide thorough mixing of the reaction products and diluent air should also be constructed of glass, Teflon, or other non-reactive material.

The output manifold should be constructed of glass, Teflon, or other non-reactive material and should be of sufficient diameter to insure an insignificant pressure drop at the analyzer connection. The system must have a vent designed to insure atmospheric pressure at the manifold and to prevent ambient air from entering the manifold.

Reagents

NO Concentration Standard. A cylinder containing 50 to 100 ppm NO in N_2 with less than 1 ppm NO_2 is usually used as the concentration standard. The cylinder must be traceable to a National Institute of Standards and Technology (NIST) NO in N_2 Standard Reference Material or NO_2 Standard Reference Material. Procedures for certifying the NO cylinder (working standard) against an NIST traceable NO or NO_2 standard and for determining the amount of NO_2 impurity are given in EPA Publication No. EPA-600/4-75-003, "Technical Assistance Document for the Chemiluminescence Measurement of Nitrogen Dioxide." In addition, the procedure for the certification of a NO working standard against an NIST traceable NO standard and determination of the amount of NO_2 impurity in the working standard is reproduced here. The cylinder should be recertified on a regular basis as determined by the local quality control program.

Use the NIST traceable NO standard and the GPT calibration procedure to calibrate the NO, NO_x, and NO_2 responses of the Model 42C. Also determine the converter efficiency of the analyzer. Refer to the calibration procedure in this manual and in the Code of Federal Regulations, Title 40, Part 50, Appendix F for exact details. Ignore the recommended zero offset adjustments.

Generate several NO concentrations by dilution of the NO working standard. Use the nominal NO concentration, $[NO]_{NOM}$, to calculate the diluted concentrations. Plot the analyzer NO response (in ppm) versus the nominal diluted NO concentration and determine the slope, S_{NOM}. Calculate the [NO] concentration of the working standard, $[NO]_{STD}$, from

$$[NO]_{STD} = [NO]_{NOM} \times S_{NOM}$$

If the nominal NO concentration of the working standard is unknown, generate several NO concentrations to give on-scale NO responses. Measure and record F_{NO} and F_T for each NO concentration generated. Plot the analyzer NO response versus F_{NO}/F_T and determine the slope which gives $[NO]_{STD}$ directly.

The analyzer NO_x responses to the generated NO concentrations reflect any NO_2 impurity in the NO working standard. Plot the difference between the analyzer NO_x and NO responses versus F_{NO}/F_T. The slope of this plot is $[NO_2]_{IMP}$.

In the procedure above, it is possible to assay the NO content of the working standard without first calibrating the NO and NO_x responses of the analyzer. This is done by simply comparing relative NO responses of the working NO standard to the NIST traceable NO standard. The NO_2 impurity can be determined from the analyzer NO_x responses provided the converter efficiency is known.

Zero air. A source of zero air free of contaminants should be used, as described earlier in this chapter. Contaminants can cause a detectable response on the Model 42C and may also react with the NO, O_3, or NO_2 during the gas phase titration.

Dynamic Parameter Specifications for Gas Phase Titrator

The O_3 generator air flow rate and the NO flow rate (see Figure 4-1) must be adjusted such that the following relationships hold:

$$P_R = [NO]_{RC} \times t_R \geq 2.75 \, \text{ppm - min}$$

$$[NO]_{RC} = [NO]_{STD} \frac{F_{NO}}{(F_O + F_{NO})}$$

$$t_R = \frac{V_{RC}}{F_O + F_{NO}} < 2 \, \text{min}$$

where:

P_R = Dynamic parameter specification to ensure complete reaction of the available O_3, ppm-min

$[NO]_{RC}$ = NO concentration in the reaction chamber, ppm

t_R = residence time of the reactant gases in the reaction chamber, min

$[NO]_{STD}$ = Concentration of the undiluted NO standard, ppm

F_{NO} = NO flow rate, sccm

F_O = O_3 generator air flow rate, sccm

V_{RC} = Volume of the reaction chamber, cc

The flow conditions to be used in the GPT system are determined by the following procedure:

1. Determine F_T, the total flow required at the output manifold, which should be equal to the analyzer demand plus 10 to 50 percent excess.

2. Establish $[NO]_{OUT}$ as the highest NO concentration that will be required at the output manifold. $[NO]_{OUT}$ should be about equal to 90% of the upper range limit (URL) of the NO_2 concentration range to be covered.

3. Determine F_{NO} as:

$$F_{NO} = \frac{[NO]_{OUT} \times F_T}{[NO]_{STD}}$$

4. Select a convenient or available reaction chamber volume. Initially a trial volume may be selected in the range of 200 to 500 cc.

5. Compute F_O as:

$$F_O = \sqrt{\frac{[NO]_{STD} \times F_{NO} \times V_{RC}}{2.75}} - F_{NO}$$

6. Compute t_R as:

$$t_R = \frac{V_{RC}}{F_O + F_{NO}}$$

Verify that $t_R < 2$ minutes. If not, select a reaction chamber with a smaller V_{RC}.

7. Compute the diluent air flow rate as:

$$F_D = F_T - F_O - F_{NO}$$

8. If F_O turns out to be impractical for the desired system, select a reaction chamber having a different V_{RC} and recompute F_D and F_O.

PRE-CALIBRATION

Follow the steps below before calibrating the Model 42C:

1. Allow the instrument to warm up and stabilize.
2. Be sure the ozonator is on. If the ozonator is not on, choose Instrument Controls from the Main Menu. From the Instrument Controls menu choose Ozonator. Press the **ENTER** pushbutton to turn the ozonator on. Press the **RUN** pushbutton to return to the Run screen.
3. Be sure the instrument is in the auto mode, that is, NO, NO_2, and NO_x measurements are being displayed on the front panel display. If the analyzer is not in the auto mode, choose Instrument Controls from the Main Menu. From the Instrument Controls menu Choose Auto/Manual Mode. Use the ↑ pushbutton to select auto mode (NO/NO_x) and press **ENTER**. Press the **RUN** pushbutton to return to the Run screen.
4. Select the NO, NO_2, and NO_x ranges and set the averaging time. It is recommended that a higher averaging time be used for best results. For more information about the ranges or averaging time, see Chapter 3, "Operation."
5. Set the calibration pressure to the current reactor pressure.
6. Verify that any filters used during normal monitoring are also used during calibration.
7. Connect the analog/digital outputs to a strip chart recorder(s).

CALIBRATION

Note that with a Model 42C equipped with internal zero/span and sample valves, the **ZERO** and **SPAN** ports should give identical responses to the sample port when test gases are introduced. The user should calibrate the Model 42C using the sample port to introduce the zero and span gas sources. After calibration, the zero and span sources should be plumbed to the appropriate ports on the rear panel of the Model 42C, and then reintroduced to the instrument. The Model 42C should give identical responses to the test gases whether they are introduced via the sample port or the zero or span ports. If not, the plumbing and/or valves should be serviced.

The following procedure discusses calibration of the Model 42C analyzer using the gas phase titrator and zero gas generator previously described. It is suggested that a calibration curve have at least seven points between the zero and full scale NO concentrations. Although the seven-point curve is optional, two of whatever number of points is chosen should be located at the zero and 90% levels and the remaining points equally spaced between these values.

Connection of GPT Apparatus to the Model 42C

1. Assemble a dynamic calibration system such as the one shown in Figure 4-1.

2. Ensure that all flowmeters are calibrated under the conditions of use against a reliable standard, such as a soap-bubble meter or wet-test meter. All volumetric flow rates should be corrected to 25°C and 760 mm Hg.

3. Precautions should be taken to remove O_2 and other contaminants from the NO pressure regulator and delivery system prior to the start of calibration to avoid any conversion of NO to NO_2. Failure to do so can cause significant errors in calibration. This problem can be minimized by (1) carefully evacuating the regulator after the regulator has been connected to the cylinder and before opening the cylinder valve; (2) thoroughly flushing the regulator and delivery system with NO after opening the cylinder valve; and (3) not removing the regulator from the cylinder between calibrations unless absolutely necessary.

4. Connect the analyzer sample bulkhead input to the output of the GPT system.

Adjustment of Instrument Gain

1. Determine the GPT flow conditions required to meet the dynamic parameter specifications as indicated in "Dynamic Parameter Specifications for Gas Phase Titrator" earlier in this chapter.

2. Adjust the GPT diluent air and O_3 generator air flows to obtain the flows determined in "Dynamic Parameter Specifications for Gas Phase Titrator" earlier in this chapter. The total GPT air flow must exceed the total demand of the analyzer. The Model 42C requires approximately 700 cc/min of sample flow and a total GPT air flow of at least 1.5 liters/min is recommended. Allow the Model 42C to sample zero air until stable NO, NO_x, and NO_2 responses are obtained. After the responses have stabilized, choose Calibration from the Main Menu. From the Calibration menu choose Calibrate Zero. The Calibrate Zero screen displays the NO and NO_x readings. Press **ENTER** to set the NO and NO_x readings to zero. The message "SAVING PARAMETER(S)" is briefly displayed to indicate that the NO and NO_x background readings have been set to zero. Press the **RUN** pushbutton to return to the Run screen. Record the stable zero air responses as Z_{NO}, Z_{NOX}, and Z_{NO2} (recorder response, % scale).

3. Adjust the NO flow from the standard NO cylinder to generate a NO concentration of about 80% of the upper range limit (URL) of the NO range. The exact NO concentration is calculated from:

$$[NO]_{OUT} = \frac{F_{NO} \times NO_{STD}}{F_{NO} + F_O + F_D} \qquad\qquad \textit{Equation 4-10}$$

Where:

$[NO]_{OUT}$ = Diluted NO concentration at the output manifold, ppm

NO_{STD} = No feed concentration

F_{NO} = No flow

F_O = Ozone flow

F_D = Dilution flow

Allow the analyzer to sample the NO calibration gas until the NO, NO_2, and NO_x readings have stabilized. After the responses have stabilized, choose Calibration from the Main Menu. From the Main Menu choose Calibrate NO. The second line of the Calibrate NO screen displays the current NO reading. The third line of the display is where the NO calibration gas concentration is entered. Use the $\leftarrow$ and $\rightarrow$ pushbuttons to move the cursor right and left and use $\uparrow$ and $\downarrow$ pushbuttons to increment and decrement each digit. Press the **ENTER** pushbutton to calibrate the NO channel to the NO calibration gas. The message "SAVING PARAMETER(S)" is briefly displayed to indicate that the NO span coefficient has been calculated, stored, and is being used to correct the NO reading.

The NO recorder response will equal:

$$\text{Recorder Response (\% scale)} = \frac{[NO]_{OUT}}{URL} \text{ x } 100 + Z_{NO} \qquad \textit{Equation 4-11}$$

Where:

URL = Nominal upper range limit of the NO channel, ppm

Record the $[NO]_{OUT}$ concentration and the Model 42C NO response as indicated by the recorder response.

4. Press the **MENU** pushbutton to return to the Calibration menu and choose Calibrate NO_x. Verify that the NO_x calibration gas concentration is the same as the NO calibration gas concentration plus any known NO_2 impurity. Use the $\leftarrow$ and $\rightarrow$ pushbuttons to move the cursor right and left and use $\uparrow$ and $\downarrow$ pushbuttons to increment and decrement each digit. Press the **ENTER** pushbutton to calibrate the NO_x channel to the NO_x calibration gas. The message "SAVING PARAMETER(S)" is briefly displayed to indicate that the NO_x span coefficient has been calculated, stored, and is being used to correct the NO_x reading. Press the **RUN** pushbutton to return to the Run screen. The exact NO_x concentration is calculated from:

$$[NO_x]_{OUT} = \frac{F_{NO} \text{ x } ([NO]_{STD} + [NO_2]_{IMP})}{F_{NO} + F_O + F_D} \qquad \textit{Equation 4-12}$$

Where:

$[NO_x]_{OUT}$ = diluted NO_x concentration at the output manifold, ppm

$[NO_2]_{IMP}$ = concentration of NO_2 impurity in the standard NO cylinder, ppm

The NO_x recorder response will equal:

$$\text{Recorder Response (\% scale)} = \frac{[NO_x]_{OUT}}{URL} \times 100 + Z_{NO_x}$$ *Equation 4-13*

Where:

URL = Nominal upper range limit of the NO_x channel, ppm

Record the NO_x concentration and the analyzer's NO_x response.

Preparation of NO, NO$_x$, and NO$_2$ Calibration Curves

1. Generate several additional NO and NO_x concentrations by decreasing F_{NO} or increasing F_D. For each concentration generated, calculate the exact NO and NO_x concentrations using the above equations for $[NO]_{OUT}$ and $[NO_x]_{OUT}$. Record the NO and NO_x responses. Plot the Model 42C responses versus the respective calculated NO and NO_x concentrations and draw or calculate the respective calibration curves. For subsequent calibrations where linearity can be assumed, these curves may be checked with a three-point calibration consisting of a zero point, NO and NO_x concentrations of approximately 80% of the URL, and an intermediate concentration.

2. Adjust the GPT system to generate a NO concentration near 90% of the URL of the instrument range selected. Sample this NO concentration until the NO and NO_x responses have stabilized. Measure and record the NO concentration as $[NO]_{ORIG}$.

3. Adjust the O_3 generator in the GPT system to generate sufficient O_3 to produce a decrease in the NO concentration equivalent to about 80% of the URL of the NO_2 range. The decrease must not exceed 90% of the NO concentration determined in step 2 above. After the analyzer responses have stabilized, record the resultant NO concentrations as $[NO]_{REM}$. Choose Calibration from the Main Menu. From the Main Menu choose Calibrate NO_2. The second line of the Calibrate NO_2 screen displays the current NO_2 reading. The third line of the display is where the NO_2 calibration gas concentration is entered. Set the NO_2 calibration gas concentration to reflect the sum of the following: the NO_2 concentration generated by GPT, ($[NO]_{ORIG}$ - $[NO]_{REM}$), and any NO_2 impurity.

$$[NO_2]_{OUT} = ([NO]_{ORIG} - [NO]_{REM}) + \frac{F_{NO} \times [NO_2]_{IMP}}{F_{NO} + F_O + F_D}$$ *Equation 4-14*

Where:

$[NO_2]_{OUT} =$ diluted NO_2 concentration at the output manifold, ppm

$[NO]_{ORIG} =$ original NO concentration, prior to addition of O_3, ppm

$[NO]_{REM} =$ NO concentration remaining after addition of O_3, ppm

Use the ← and → pushbuttons to move the cursor right and left and use ↑ and ↓ pushbuttons to increment and decrement each digit. Press the **ENTER** pushbutton to calibrate the NO_2 channel to the NO_2 calibration gas. The message "SAVING PARAMETER(S)" is briefly displayed to indicate that the NO_2 span coefficient has been calculated, stored, and is being used to correct the NO_2 reading.

The Model 42C does a one point NO_2 span coefficient calculation, corrects the NO_2 reading for converter inefficiency, and then adds the corrected NO_2 to the NO signal to give a corrected NO_x signal. If the Model 42C calculates a NO_2 span coefficient of less than 0.96, either the entered NO_2 concentration is incorrect, the converter is not being heated to the proper temperature, the instrument needs servicing (leak or imbalance), or the converter needs replacement or servicing. The NO_2 analog output will reflect the NO_2 concentration generated by GPT, any NO_2 impurity, and the NO_2 zero offset.

The recorder response will be as follows:

$$\text{Recorder Response (\% scale)} = \frac{[NO_2]_{OUT}}{URL} \times 100 + Z_{NO_2} \qquad \textit{Equation 4-15}$$

Where:

URL = Nominal upper range limit of the NO_2 channel, ppm

Record the NO_2 concentration and the analyzer's NO_2 response.

4. Maintaining the same F_{NO}, F_O, and F_D, adjust the ozone generator to obtain several other concentrations of NO_2 over the NO_2 range (at least five evenly spaced points across the remaining scale are suggested).

Record the stable responses and plot the analyzer's NO_2 responses versus the corresponding calculated (using the above equation for $[NO_2]_{OUT}$) concentrations and draw or calculate the NO_2 calibration curve. It is important that the curve be linear within ± 1 % FS over the NO_2 range. If the curve is nonlinear, the analyzer is not operating correctly, e.g., leak, converter failure, etc., and should be serviced. Assuming the curve is linear, subsequent data should be reduced using this NO_2 calibration curve.

5. Note that using the Calibration Factors menu can change the calibration factors. This is often useful in a troubleshooting situation. However, after the above calibration procedure is completed, all subsequent data reduction depends on the calibration parameters, remaining the same as during the initial calibration. Therefore never change any calibration factor without first recording the value so that after any troubleshooting procedure is completed, the initial value can be re-entered thereby not altering the multipoint calibration.

Alternative Calibration Procedure Using NO₂ Permeation Tube

Although Thermo Environmental recommends that a GPT system be used to calibrate the Model 42C, the procedure described in the Code of Federal Regulations, Title 40, Part 50, Appendix F using a NO_2 permeation tube may be used as an alternative procedure for calibration of the Model 42C.

CALIBRATION IN DUAL RANGE AND AUTO RANGE MODE

The dual/auto range calibration feature is used to calibrate the analyzer at two different span levels (as opposed to a single span level in the standard mode) generating a "tailored multi-point" calibration curve stored in the analyzer's memory. This feature may be used when widely different gas levels are being monitored, e.g., a factor of 10 or greater apart, or if precision and span levels are being introduced using separate tanks, or if more than one multi-component cylinder is being used to calibrate the instrument. Properly designed chemiluminescence analyzers are inherently linear over a wide dynamic range; therefore under normal USEPA compliance situations this feature is not required. Dual calibration may be used for span levels less than a factor of 10 apart, however if this is done to correct for a significant non-linearity, it may mask the problems causing the effect, e.g., bad calibration cylinder, leaks in sampling lines, low ozonator output, etc.

To calibrate the Model 42C in dual or auto range mode follow the procedure below:

1. Follow the procedure described in "Pre-Calibration" earlier in this chapter.

2. Introduce zero air to the **SAMPLE** bulkhead. Allow the analyzer to sample zero air until stable NO, NO_x, and NO_2 responses are obtained. After the responses have stabilized, choose Calibration from the Main Menu. From the Calibration menu

choose Calibrate Zero. The Calibrate Zero **screen** displays the NO and NO_x readings. Press **ENTER** to set the NO and NO_x readings to zero. The message "SAVING PARAMETER (S)" is briefly displayed to indicate that the NO and NO_x background readings have been set to zero. Press the **RUN** pushbutton to return to the Run screen.

3. Disconnect the source of zero air from the **SAMPLE** bulkhead. In its place, connect a source of NO calibration gas of about 80% of the low NO full-scale range. Allow the analyzer to sample the low NO calibration gas until the NO, NO_2, and NO_x readings have stabilized. After the responses have stabilized, choose Calibration from the Main Menu. From the Main Menu choose Calibrate LO NO. The second line of the Calibrate NO screen displays the current NO reading. The third line of the display is where the NO calibration gas concentration is entered. Use the ← and → pushbuttons to move the cursor right and left and use ↑ and ↓ pushbuttons to increment and decrement each digit. Press the **ENTER** pushbutton to calibrate the NO channel to the NO calibration gas. The message "SAVING PARAMETER (S)" is briefly displayed to indicate that the low NO span coefficient has been calculated, stored, and is being used to correct the NO reading.

4. Press the **MENU** pushbutton to return to the Calibration menu and choose Calibrate LO NO_x. Verify that the low NO_x calibration gas concentration is the same as the low NO calibration gas concentration plus any known NO_2 impurity. Use the ← and → pushbuttons to move the cursor right and left and use ↑ and ↓ pushbuttons to increment and decrement each digit. Press the **ENTER** pushbutton to calibrate the NO_x channel to the NO_x calibration gas. The message "SAVING PARAMETER(S)" is briefly displayed to indicate that the low NO_x span coefficient has been calculated, stored, and is being used to correct the NO_x reading. Press the **RUN** pushbutton to return to the Run screen.

5. Adjust the O_3 generator in the GPT system to generate sufficient O_3 to produce a decrease in the low NO concentration equivalent to about 80% of the URL of the low NO_2 range. The decrease must not exceed 90% of the low NO concentration determined in step 4. Choose Calibration from the Main Menu. From the Main Menu choose Calibrate LO NO_2. The second line of the Calibrate LO NO_2 screen displays the current NO_2 reading. The third line of the display is where the low NO_2 calibration gas concentration is entered. Set the low NO_2 calibration gas concentration to reflect the sum of the following: the NO_2 concentration generated by GPT and any NO_2 impurity.

    Use the ← and → pushbuttons to move the cursor right and left and use ↑ and ↓ pushbuttons to increment and decrement each digit. Press the **ENTER** pushbutton to calibrate the NO_2 channel to the NO_2 calibration gas. The message "SAVING PARAMETER (S)" is briefly displayed to indicate that the low NO_2 span coefficient has been calculated, stored, and is being used to correct the NO_2 reading.

6. Connect a source of high NO calibration gas of about 80% of the high NO full-scale range. Allow the analyzer to sample the high NO calibration gas until the NO, NO_2, and NO_x readings have stabilized. After the responses have stabilized, choose Calibration from the Main Menu. From the Main Menu choose Calibrate HI NO. The second line of the Calibrate NO screen displays the current NO reading. The third line of the display is where the high NO calibration gas concentration is entered. Use the ← and → pushbuttons to move the cursor right and left and use ↑ and ↓ pushbuttons to increment and decrement each digit. Press the **ENTER** pushbutton to calibrate the NO channel to the NO calibration gas. The message "SAVING PARAMETER (S)" is briefly displayed to indicate that the high NO span coefficient has been calculated, stored, and is being used to correct the NO reading.

7. Press the **MENU** pushbutton to return to the Calibration menu and choose Calibrate HI NO_x. Verify that the high NO_x calibration gas concentration is the same as the high NO calibration gas concentration plus any known NO_2 impurity. Use the ← and → pushbuttons to move the cursor right and left and use ↑ and ↓ pushbuttons to increment and decrement each digit. Press the **ENTER** pushbutton to calibrate the NO_x channel to the NO_x calibration gas. The message "SAVING PARAMETER (S)" is briefly displayed to indicate that the high NO_x span coefficient has been calculated, stored, and is being used to correct the NO_x reading. Press the **RUN** pushbutton to return to the Run screen.

8. Adjust the O_3 generator in the GPT system to generate sufficient O_3 to produce a decrease in the high NO concentration equivalent to about 80% of the URL of the high NO_2 range. The decrease must not exceed 90% of the high NO concentration determined in step 7. Choose Calibration from the Main Menu. From the Main Menu choose Calibrate HI NO_2. The second line of the Calibrate HI NO_2 screen displays the current NO_2 reading. The third line of the display is where the high NO_2 calibration gas concentration is entered. Set the high NO_2 calibration gas concentration to reflect the sum of the following: the NO_2 concentration generated by GPT and any NO_2 impurity.

    Use the ← and → pushbuttons to move the cursor right and left and use ↑ and ↓ pushbuttons to increment and decrement each digit. Press the **ENTER** pushbutton to calibrate the NO_2 channel to the NO_2 calibration gas. The message "SAVING PARAMETER (S)" is briefly displayed to indicate that the high NO_2 span coefficient has been calculated, stored, and is being used to correct the NO_2 reading.

9. The calibration factors can be changed by using the Calibration Factors menu. This is often useful in a troubleshooting situation. However, after the above calibration procedure is completed, all subsequent data reduction depends on the calibration parameters, remaining the same as during the initial calibration. Therefore never change any calibration factor without first recording the value so that after any troubleshooting procedure is completed, the initial value can be re-entered thereby not altering the multipoint calibration.

ZERO AND SPAN CHECK

The Model 42C requires initial and periodic calibration according to the procedures outlined above. Initially, the frequency of the calibration procedure should be determined by the stability of the zero and span checks. When zero and span checks, which may be run daily, indicate a shift in instrument gain of more than 10 percent from that determined during the most recent multipoint calibration, a new calibration curve should be generated. As confidence in the Model 42C is gained, the frequency of calibration, and even zero and span checks, can be adjusted appropriately. The instrument user should have a quality control plan whereby the frequency and the number of points required for calibration can be modified on the basis of calibration and zero and span check data collected over a period of time (however note that the EPA requires a minimum of one multipoint calibration per calendar quarter). Such a quality control program is essential to ascertain the accuracy and reliability of the air quality data collected and to alert the user if the accuracy or reliability of the data should become unacceptable. A compilation of this kind might include items such as dates of calibration, atmospheric conditions, calibration factors, and other pertinent data.

1. Allow the Model 42C to sample zero gas until a stable reading is obtained on the NO, NO_2, and NO_x channels (the zero gas is plumbed to the **SAMPLE** bulkhead in a standard instrument or to the **ZERO** bulkhead in a Model 42C equipped with the zero/span and sample solenoid valve option). Record the zero readings. Unless the zero has changed by more than ± 0.010 ppm, it is recommended that the zero not be adjusted. If an adjustment larger than this is indicated due to a change in zero reading, a new multipoint calibration curve should be generated.

2. Attach a supply of known concentration of NO and NO_2 (usually generated via an NIST traceable NO working standard and a GPT system) to the **SAMPLE** bulkhead (or **SPAN** bulkhead for instruments equipped with the zero/span and sample solenoid valve option) on the rear panel. Allow the Model 42C to sample the calibration gas until a stable reading is obtained on the NO, NO_2, and NO_x channels. If the calibration has changed by more than $\pm 10\%$, a new multipoint calibration curve should be generated.

3. When the calibration check has been completed, record the NO, NO_2, and NO_x values. Reconnect the analyzer sample line to the **SAMPLE** bulkhead.

CHAPTER 5
PREVENTIVE MAINTENANCE

This chapter describes the periodic maintenance procedures that should be performed on the instrument at least once every six months to ensure proper operation.

SPARE PARTS

Table 5-1. lists the recommended spare parts.

Part Number	Description
4121	Capillary (sample) – 0.010" Diameter (use when designated as NO_x only)
4127	Capillary (sample) – 0.015" Diameter
4119	Capillary (ozone) – 0.008" Diameter
4158	Charcoal (pound)
6998	Desiccant (Drierite®)
4510	Fuse (115V) T, 3A, 250V
14007	Fuse (220V) T, 1.6A, 250V
8119	Solenoid valve
4800	O-ring - capillary (pk/10)
4320	Filter elements (pk/25)
9263	Pump - 110 volts
9262	Pump - 220 volts
9267	Pump repair kit
9269	Molybdenum converter cartridge
13983	Band heater (110 volts)
13982	Band heater (220 volts)
6556	Filter kit optical
9996	Model 42C Instruction Manual

REPLACEMENT OF OZONATOR AIR FEED DRYING COLUMN

1. Remove the drying column from the connector **DRY AIR** bulkhead on the rear panel of the Model 42C.
2. Replace spent absorbent material (indicating Drierite® or silica gel) with regenerated material.
3. Reinstall the drying column to the **DRY AIR** bulkhead.
4. Perform a zero/span check.

INSPECTION AND REPLACEMENT OF SAMPLE FILTER

The Teflon particulate filter in the Model 42C should be inspected regularly and, if necessary, replaced. A filter that does not interact with NO or NO_2 in air should be employed. A suitable filter element is available from Thermo Environmental Instruments. The filter should have a 5 (or 2) micron pore size. The filter should be replaced on a regular maintenance schedule to prevent the absorption of sample gas by trapped material on the filter. Initially, the filter should be inspected more frequently until an appropriate maintenance schedule is determined. Perform a zero/span check after filter replacement.

INSPECTION AND REPLACEMENT OF CAPILLARIES

The following procedure should be performed every three months. The procedure can be used to check any or all of the capillaries.

> **CAUTION:** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, "Servicing."

1. Turn the instrument off and unplug the power cord.
2. Remove the instrument cover.
3. Locate the capillary holders (see Figure 7-2).
4. Remove the Cajon® fitting(s) from the reaction chamber body using a 5/8" wrench.
5. Remove the glass capillary(s) and O-ring. Inspect O-ring for cuts or abrasion. If cut or abraded, replace.
6. Check capillary for particulate deposits. Clean or replace as necessary.

7. Replace capillary in reaction chamber body, making sure the O-ring is around the capillary before inserting it into the body.
8. Replace Cajon fitting. Note that the Cajon fitting should be replaced only hand tight.
9. Re-install the instrument cover.

DIGITAL TO ANALOG CONVERTER TEST

The digital to analog converter test is used to fully test the analog outputs. It is normally performed only when a problem with the analog outputs is suspected. From the Main Menu choose Diagnostics. From the Diagnostics menu choose Test Analog Outputs. From the Test Analog Output menu choose Ramp. The analog outputs start at -2.3% (-23) and then increment by one every second until it reaches 100.0% (1000). A linear output indicates that the analog outputs are operating correctly.

INSPECTION AND CLEANING THERMOELECTRIC COOLER FINS

The cooler fins on the photomultiplier tube (PMT) cooler should be inspected and cleaned every six month. This ensures optimum performance.

CAUTION: Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, "Servicing."

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1. Turn the instrument off and unplug the power cord.
2. Remove the instrument cover.
3. Locate the PMT cooler (Figures 7-2 and 7-4).
4. Blow off the cooler fins using clean pressurized air. It may be more convenient to vacuum the cooler fins. In either case, make sure that any particulate accumulation between the fins has been removed.
5. If necessary, use a small brush to remove residual particulate accumulation.
6. Replace the instrument cover.

INSPECT AND CLEAN FAN FILTERS

Under normal use, the fan filters on the rear panel should be cleaned every six months. If the instrument is operated in excessively dirty surroundings, it may be necessary to clean the fan filters more frequently.

1. Remove the two fan guards from the fans.
2. Flush the filters with warm water and let dry (a clean, oil-free purge will help the drying process).
3. Re-install the filters and fan guards.

CHAPTER 6
TROUBLESHOOTING

The Model 42C has been designed to achieve a high level of reliability. Only premium components are used, thus complete failure is rare. In the event of problems or failure, the troubleshooting guidelines presented in this chapter should be helpful in isolating the fault(s). The Service Department at Thermo Environmental can also be consulted in the event of problems at (508) 520-0430. In any correspondence with the factory, please note both the serial number and program number of the instrument.

CAUTION: Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, "Servicing."

TROUBLESHOOTING GUIDE

MALFUNCTION	POSSIBLE CAUSE	ACTION
Does not start up	No power	Check that the instrument is plugged into the proper source (115 or 220 volts)
		Check instrument fuses
	Power supply	Check voltages (Diagnostics menu)
	Digital electronics	Unplug power cord. Check that all boards are seated properly

MALFUNCTION	POSSIBLE CAUSE	ACTION
Does not start up (continued)		Unplug power cord. Remove one board. Install known good board. Repeat until faulty board is detected.
No output signal (or very low output)	No sample gas reaching the analyzer	Check input sample flow
	Blocked sample capillary	Unplug power cord. Clean or replace capillary
	No ozone reaching the reaction chamber	Check if the ozonator is on (Instrument Control menu). If so, check **DRY AIR** supply
No output signal	Disconnected or defective input or high voltage supply	Unplug power cord. Check that cables are connected properly. Check resistance of cables
	Analyzer not calibrated	Recalibrate
	Defective ±15 volt	Check supply voltages (Diagnostics Menu)
Calibration drift	Dryer to ozonator depleted	Replace
	Line voltage fluctuations	Check to see if line voltage is within specifications
	Unstable NO or NO_2 source	Replace

MALFUNCTION	POSSIBLE CAUSE	ACTION
Calibration drift (continued)	Clogging capillaries	Unplug power cord. Clean or replace capillary
	Clogged sample air filter	Replace filter element
Excessive noise	Defective or low sensitivity PMT	Unplug power cord. Remove PMT. Install known good PMT. Plug in power cord. Check performance
	Defective cooler	Check background values (should be less than 15 ppb) and temperature (less than -2°C at $T_{amb} = 25°C$)
Non-linear response	Incorrect calibration source	Verify accuracy of multipoint calibration source gas
	Leak in sample probe line	Check for variable dilution
Excessive response time	Partially blocked sample capillary	Unplug power cord. Clean or replace capillary
	Hang up in sample filter	Change element
Improper converter operation	Improperly known calibration gas	Verify accuracy
	Converter temperature too high or too low	Temperature should be about 325°C
	Low line voltage	Check to see if line voltage is within specifications

MALFUNCTION	POSSIBLE CAUSE	ACTION
Improper converter operation (continued)	Molybdenum consumed	Replace

CHAPTER 7
SERVICING

This chapter explains how to replace the Model 42C subassemblies. Fault location is accomplished in the preceding chapters of "Preventive Maintenance" and "Troubleshooting." This chapter assumes that a subassembly has been identified as defective and needs to be replaced. For additional service assistance, see "Servicing Locations" later in this chapter.

SAFETY PRECAUTIONS

Some internal components can be damaged by the discharge of static electricity. To avoid damaging internal components, follow these precautions when performing any service procedure:

- Wear an antistatic wrist strap that is properly connected to earth ground (note that when the analyzer is unplugged, the chassis is not at earth ground)
- If an antistatic wrist strap is not available, be sure to touch a grounded metal object before touching any internal components
- Handle all printed circuit boards by the edges
- Carefully observe the instructions in each procedure
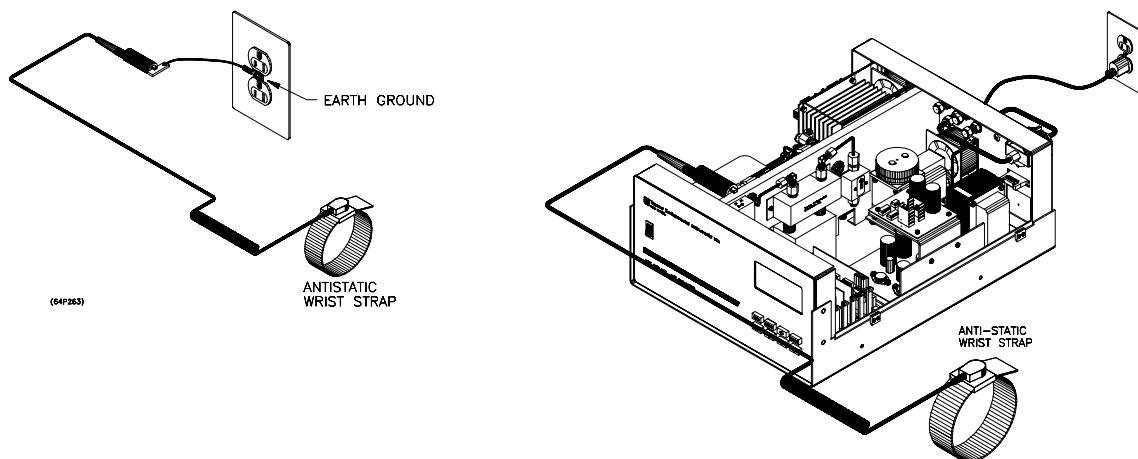
Figure 7-1. Properly Grounded Antistatic Wrist Strap

REPLACEMENT PARTS LIST

Table 7-1 lists the replacement parts for the major subassemblies in the Model 42C. Refer to Figure 7-2 to identify their location.

Table 7-1. Replacement Parts

Part Number	Description
9837	Processor Board
9841	Analog to Digital Board
9839	Digital to Analog Board
9956	Optional I/O Board
9843	C-Link Board
9827	Motherboard
9845	Power Supply Board
9946	Ozonator Board
9940	Temperature Control Board (Molybdenum Converter)
10765	Temperature Control Board (Stainless Steel Converter)
9948	Input Board
9974	Ozonator Transformer
9207	Transformer
9877	Pressure Transducer
9938	Flow Sensor (Sample)
9973	Ozonator
9367	Photomultiplier Tube (PMT)
8119	Solenoid Valve
9269	Molybdenum Converter Cartridge
9467	Stainless Steel Converter Cartridge
9445	NO_2-to-NO Converter Assembly (Molybdenum 110V)
9446	NO_2-to-NO Converter Assembly (Molybdenum 220V)
10295	NO_2-to-NO Converter Assembly (Stainless Steel 110V)
10284	NO_2-to-NO Converter Assembly (Stainless Steel 220V)
9263	Pump 110V
9262	Pump 220V
10111	Flow Switch (Ozone)
9586	Base Socket Assembly

NO.	DESCRIPTION
1	NO$_2$ TO NO CONVERTER
2	MODE SOLENOID
3	PMT COOLER
4	TEMPERATURE CONTROL BOARD
5	OZONATOR
6	OZONE FLOW SENSOR
7	SAMPLE PARTICULATE FILTER
8	TRANSFORMER
9	OZONATOR BOARD
10	POWER SUPPLY BOARD
11	MOTHER BOARD
12	C-LINK BOARD
13	OPTIONAL BOARD (I.G., I/O BOARD)
14	D/A BOARD
15	A/D BOARD
16	PROCESSOR BOARD
17	PUMP
18	OZONATOR TRANSFORMER
19	INPUT BOARD
20	SAMPLE FLOW SENSOR
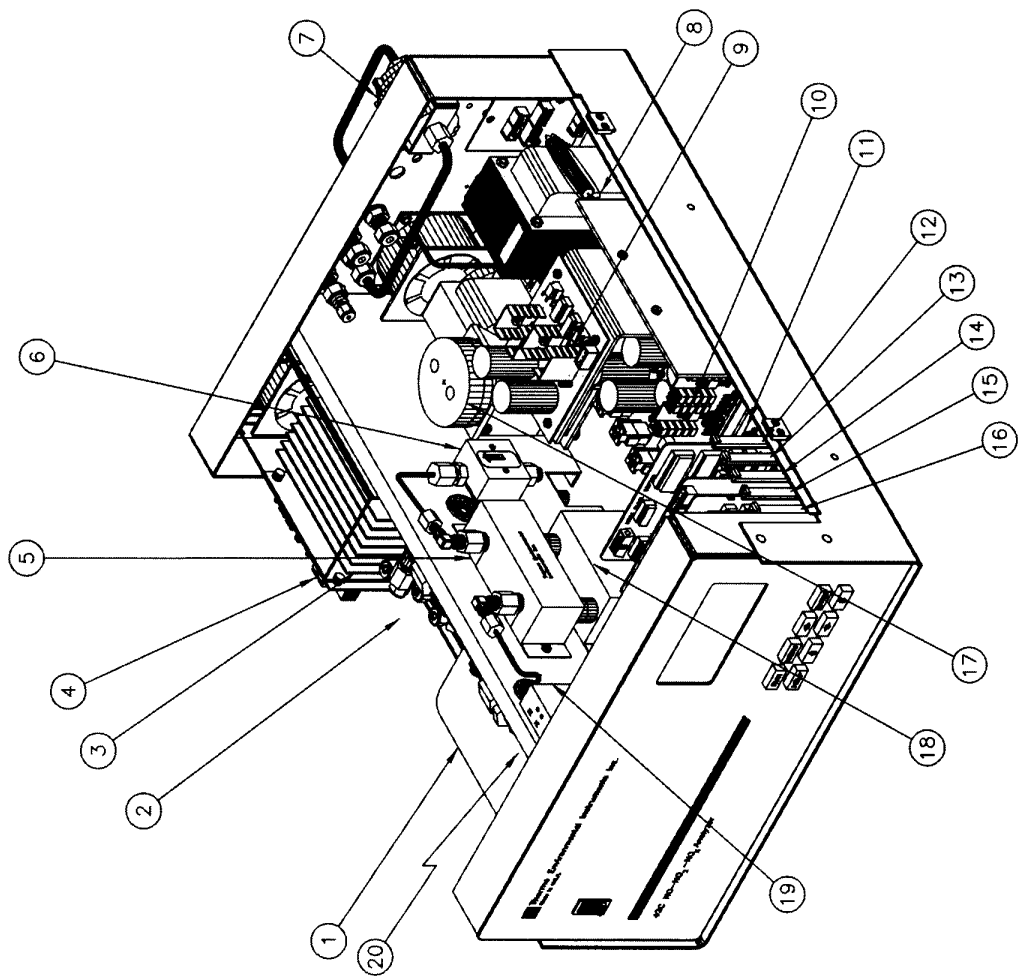
64P7204

Figure 7-2. Model 42C Component Layout

WARNING: Unplug the instrument before servicing any internal component

---

REBUILDING PUMP

Equipment Required:
Pump Repair Kit
Allen Wrench - 3 mm"
Wrench - 9/16
Needlenose Pliers

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Loosen fittings and remove both lines going to the pump.
4. Remove four screws from top plate using Allen wrench (see Figure 7-3). Remove top plate, flapper valve, and bottom plate.
5. Remove clamping disk (with needlenose pliers) holding diaphragm and Teflon protection wafer onto clamping rod. Remove both diaphragm and Teflon wafer.
6. Assemble pump by following above procedure in reverse, making sure not to over-tighten clamping disk, and to have Teflon side of diaphragm facing up and that the flapper valves cover the holes of the top and bottom plate.
7. Re-install the instrument cover.
8. Check that the reaction chamber pressure reads between 150 and 250 mm Hg.

PUMP REPLACEMENT

Equipment Required:
110V Pump or
220V Pump
Wrench - 9/16
Nut driver – 1/4"
Screwdriver

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Disconnect power line of pump from power supply board.
4. Remove both lines from pump.
5. Remove four screws holding pump mounting plate to floor plate.
6. Remove two screws holding pump to mounting plate (see Figure 7-3).
7. Install new pump by following above procedure in reverse.
8. Re-install the instrument cover.

SCREW
3mm SOC. HD.
(4) REQ.

TOP
PLATE

CONNECTOR
MALE
P/N 4422
SEE NOTE 1.

FLAPPER
VALVE

ELBOW, MALE
P/N 4430
SEE NOTE 1.

BOTTOM
PLATE

CLAMPING
DISK

TEFLON
PROTECTION
WAFER

TEFLON
COATED
DIAPHRAGM

SOCKET, FEMALE
P/N 5365
(2) REQ.

DIAPHRAGM
MOUNTING
DISK

CONNECTOR
2 POS. MALE
P/N 4609

PUMP
P/N 9263 (110V)
P/N 9262 (220V)

MOUNTING
PLATE
P/N 9240

NOTE 1:
USE TEFLON TAPE ON THREADS.
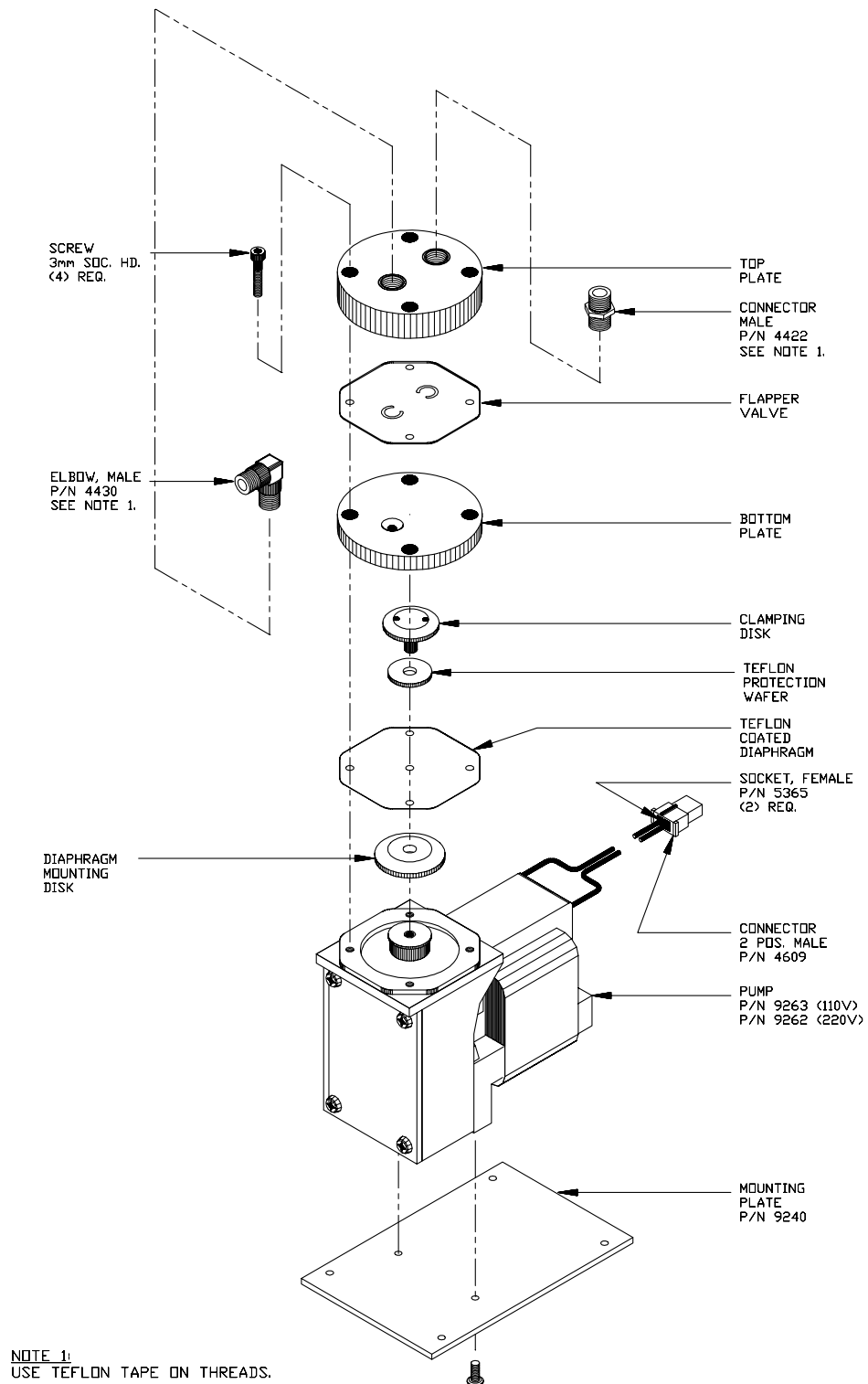
Figure 7-3. Pump Assembly

64P7173

PHOTOMULTIPLIER COOLER REPLACEMENT

Equipment Required:
    Wrench - 7/16"
    Wrench - 9/16"
    Nut driver - ¼"

This procedure is easier if the converter is removed as described in "Converter Removal" later in this chapter.

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Disconnect all connectors from temperature control board.
4. Remove plumbing connections to reaction chamber.
5. Unplug signal cable to Input Board, high voltage cable to PMT power supply, and four-pin connector to J7 on DC Power Supply Board. Pull cables through divider panel.
6. Remove four screws holding cooler to floor plate.
7. Lift cooler assembly (with reaction chamber) up and slide forward to remove.
8. Install new cooler by following above procedure in reverse.
9. Re-install the instrument cover.
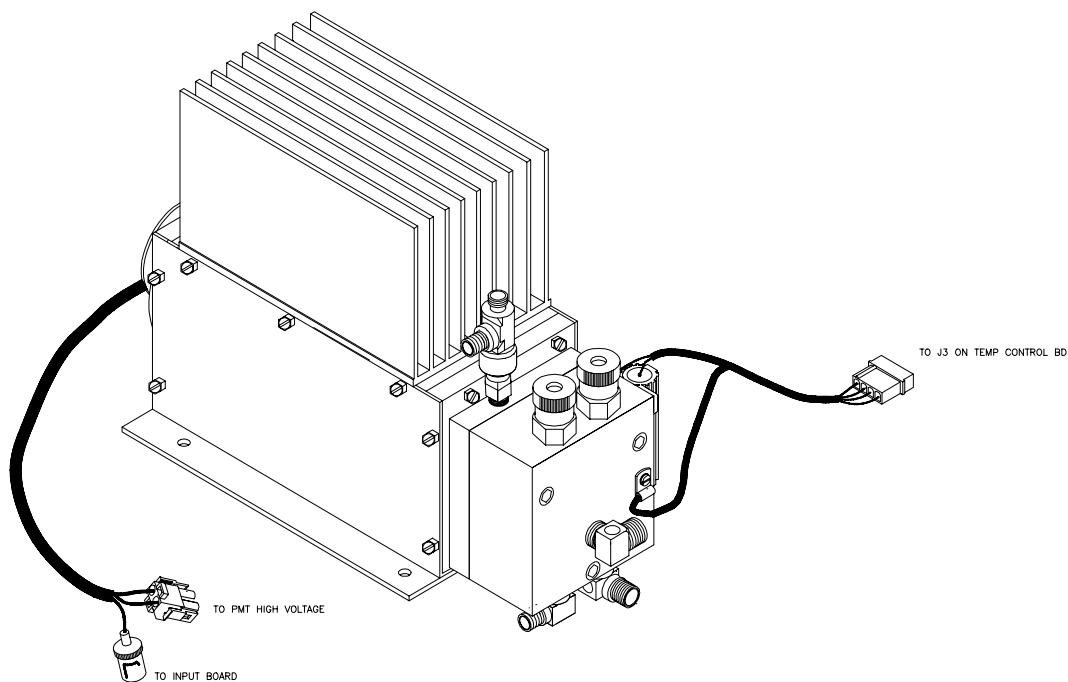
Figure 7-4. PMT Cooler and Reaction Chamber   64P7157

REPLACEMENT OF PHOTOMULTIPLIER TUBE

Equipment Required:
    PMT and PMT base
    Nut driver – 1/4"
    Nut driver - 5/16"

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Disconnect the high voltage cable to the PMT power supply and unplug the signal cable to the Input Board.
4. Remove six external #6 screws holding right panel to instrument frame. Remove right rear panel. Note that the cooler fan is attached and if necessary the fan power cord should be unplugged.
5. Pull high voltage and signal cables attached to PMT base through divider panel.
6. Remove the three retaining screws holding PMT base to cooler using 5/16" nut driver.
7. Withdraw PMT and PMT base from cooler assembly. A slight back and forth twisting motion facilitates this procedure.
8. To install PMT, follow above procedure in reverse making sure to backfill the cooler with dry air or nitrogen prior to replacing the PMT.
9. Re-install the instrument cover.

REACTION CHAMBER CLEANING AND/OR REMOVAL

Equipment Required:
    Allen Wrench - 9/64"
    Wrench - 7/16"
    Wrench - 9/16"

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Remove PMT cooler as described in "Photomultiplier Cooler Replacement" above. Note that if the NO_2-to-NO converter is removed first, as in "NO_2-to-NO Converter Removal" below, the reaction chamber can be removed without removing the entire PMT cooler.
4. Disconnect the 1/8" line at the mixing tee on the back portion of the reaction chamber. This line is connected to the left 1/8" elbow at the bottom of the front portion of the reaction chamber.
5. Disconnect 1/4" fitting from the exhaust elbow on the front portion of the reaction chamber.
6. Disconnect 1/8" fitting from right 1/8" elbow at the bottom of the front portion of the reaction chamber.
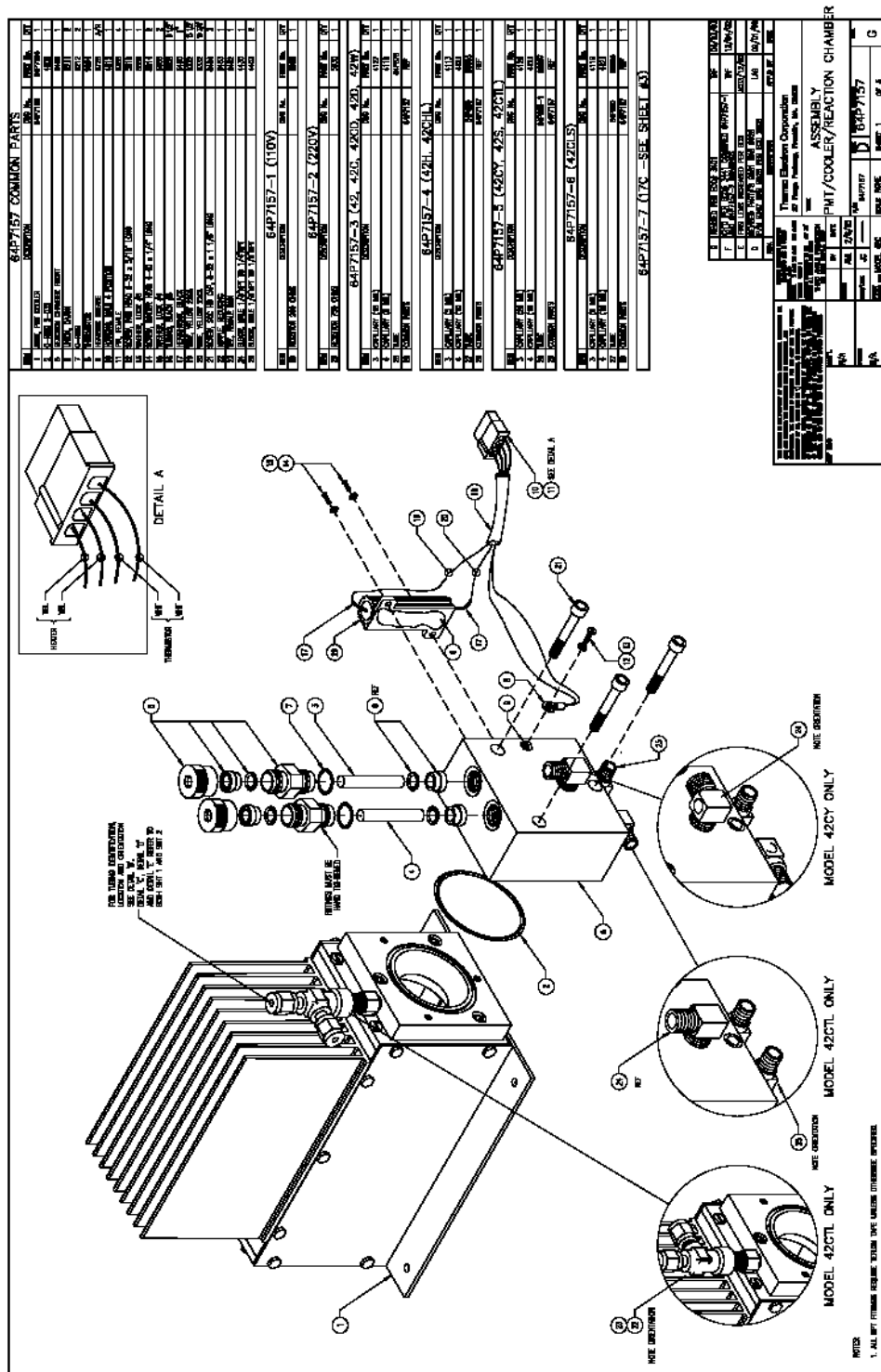
Figure 7-5. PMT Cooler and Reaction Chamber (exploded view)   64P7157

7. Disconnect four-pin connector from temperature control board.
8. Remove the three socket head screws holding front portion of reaction chamber to back portion. This exposes the inner surfaces of both portions of the reaction chamber and the quartz window. To clean these surfaces use cotton swabs and methanol.
9. To continue removing back portion of reaction chamber remove the three socket head screws holding it to cooler, being careful to keep quartz window and red filter in cooler body.
10. To reinstall reaction chamber, follow above procedures in reverse, making sure to backfill the cooler with dry air or nitrogen prior to installing reaction chamber.
11. Re-install the instrument cover.

NO$_2$-to-NO CONVERTER REPLACEMENT

Equipment Required:
    Wrench - 7/16"
    Wrench - 9/16"
    Wrench - ½"
    Wrench - 5/8"
    Screwdriver
    Nut driver – ¼"
    Nut driver - 5/16"

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Allow converter to cool to room temperature to prevent contact with heated components.
4. Disconnect plumbing at inlet and exit of converter.
5. Disconnect thermocouple leads and heater connector from Temperature Control Board.
6. Remove four screws holding converter housing to floor plate.
7. Remove six screws holding top half of converter housing to bottom half.
8. Remove converter cartridge/heater assembly from bottom converter half.
9. Loosen heater clamp, pry heater apart no wider than necessary and remove converter cartridge, noting proper orientation of heater wires and thermocouple probe.
10. To replace converter, follow above procedure in reverse.
11. Re-install the instrument cover.
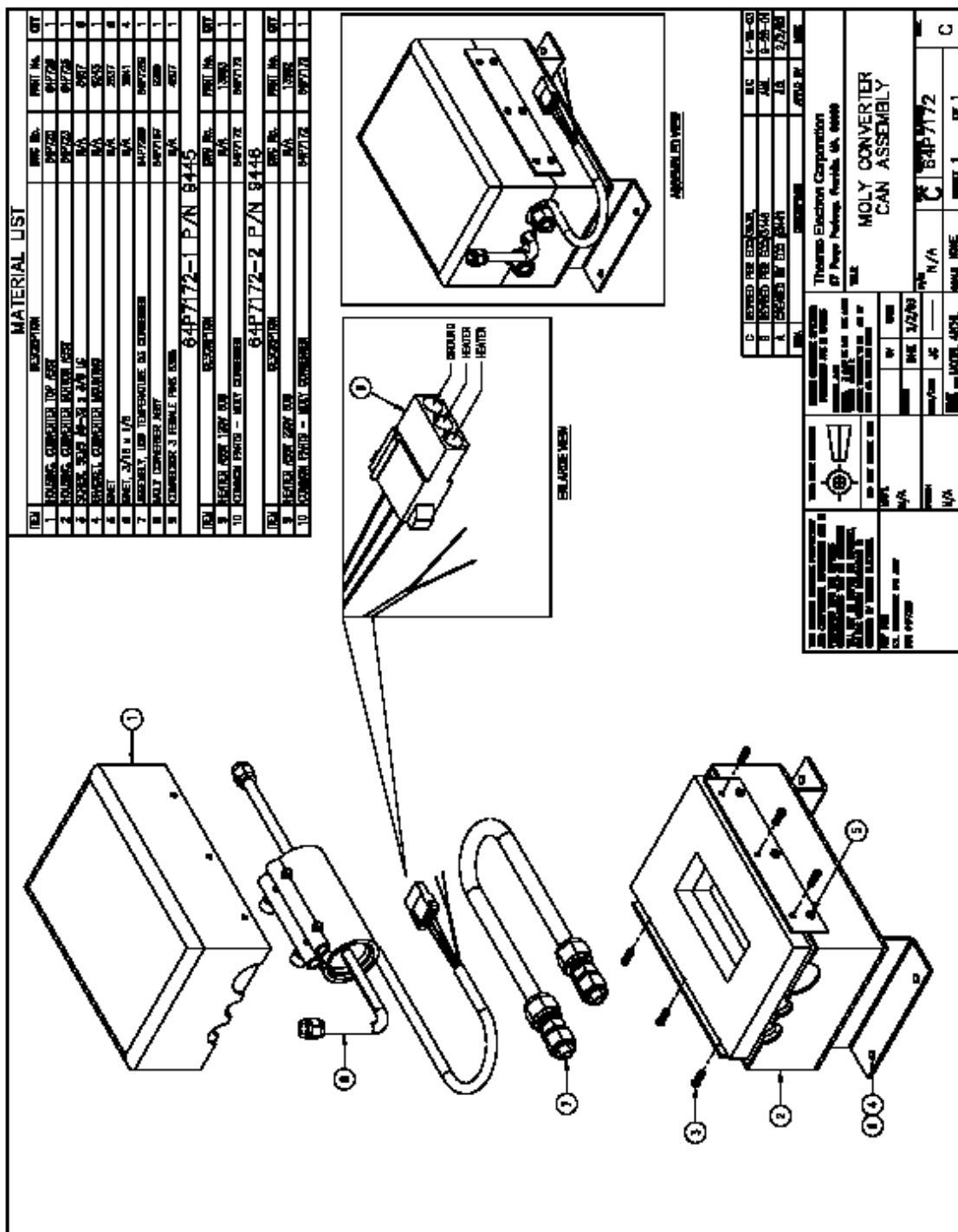
Figure 7-6. NO$_2$-to-NO Converter Assembly

64P7172

HEATERS
1. 120V 60W MOLY P/N 13983
2. 240V 60W MOLY P/N 13982
3. 120V 90W S.S. P/N 13981
4. 240V 90W S.S. P/N 13980

1. MOLY CONVERTER ASSEMBLY
   P/N 9269
2. STAINLESS STEEL CONVERTER ASSY.
   P/N 9467
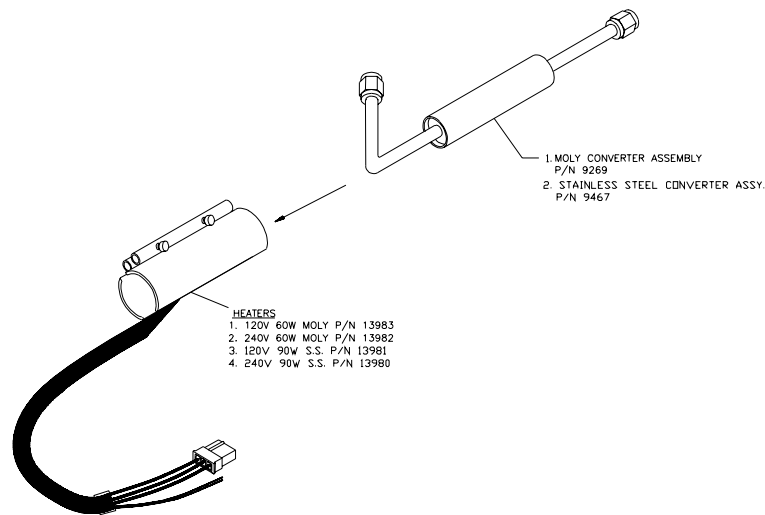
Figure 7-7. Molybdenum Converter   64P7243

SOLENOID VALVE REPLACEMENT

Equipment Required:
    Solenoid Valve
    Wrench - 5/16"

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Disconnect solenoid from DC Power Supply Board labeled NO/NO$_x$.
4. Remove Teflon plumbing at solenoid.
5. Pull solenoid valve from divider panel mounting clip.
6. To replace solenoid, follow above in reverse.
7. Re-install the instrument cover.

OZONATOR ASSEMBLY REPLACEMENT

Equipment Required:
Ozonator Assembly
Wrench - 5/8"
Nut driver – 1/4"

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Carefully disconnect the plumbing at the glass inlet and outlet of the ozonator.
4. Remove the two screws holding the ozonator to the divider panel.
5. Unplug the ozonator from the ozonator transformer by lifting the ozonator up.
6. To install the ozonator, follow the above procedure in reverse.
7. Re-install the instrument cover.

REPLACEMENT OF OZONATOR TRANSFORMER

Equipment Required:
Ozonator Transformer
Nut driver – 1/4"

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Remove the ozonator assembly as described above.
4. Disconnect the plug from the ozone transformer to the ozone supply board.
5. Remove the four screws holding transformer to the divider plate.
6. To install, follow the above procedure in reverse.
7. Re-install the instrument cover.

REMOVAL OF INPUT BOARD

Equipment Required:
Nut driver – 1/4"

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Disconnect the signal and the ribbon cables.
4. Remove the three screws holding the Input Board cover to the divider panel.
5. Disconnect jumper wire from BNC connector to the IN pin on the Input Board.
6. Remove the four screws holding the board to the divider panel.
7. Install by following the above procedure in reverse.
8. Re-install the instrument cover.

PMT HIGH VOLTAGE SUPPLY REPLACEMENT

Equipment Required:
    PMT High Voltage Supply
    Nut driver – 1/4"

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Unplug the PMT high voltage supply from the DC Power Supply Board and the PMT base.
4. Remove the converter assembly as described in section "Converter Removal" above.
5. Remove the four screws holding the high voltage supply to the divider panel.
6. Install by following the above procedure in reverse.
7. Re-install the instrument cover.

DC POWER SUPPLY REPLACEMENT

Equipment Required:
    DC Power Supply
    Nut driver - 1/4"
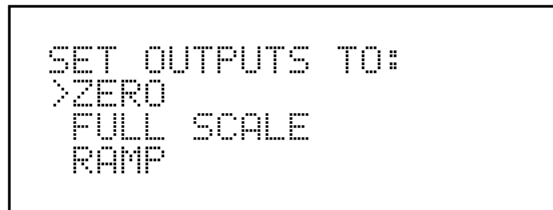
1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn instrument off, unplug the power cord, and remove the instrument cover.
3. Disconnect all the plug-in connections from the board.
4. Remove the screws holding the board to the chassis and remove the board.
5. Install by following above in reverse. Care should be taken to ensure that the voltage regulators fit into the plugs on the bottom of the board.
6. Re-install the instrument cover.

ANALOG OUTPUT ADJUSTMENT

The analog outputs need only be adjusted if the concentration value on the front panel display disagrees with the analog outputs. To see if the analog outputs need to be adjusted, compare the front panel display to the analog output voltage. If they differ by more than 1%, then the analog outputs should be adjusted. This procedure should only be performed by an instrument service technician.

1. Wear an antistatic wrist strap that is properly connected to earth ground, see "Safety Precautions," earlier in this chapter for more information.
2. Remove the instrument cover.
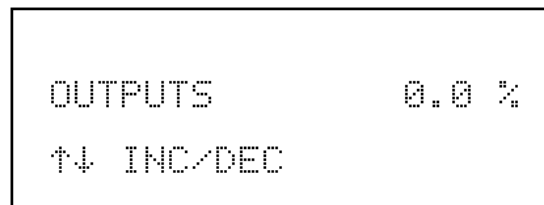
3. From the Run screen, press the **MENU** pushbutton to display the Main Menu. Use the ↓ pushbutton to move the cursor to Diagnostics, and press **ENTER** to display the Diagnostics menu. Use the ↓ pushbutton to move the cursor to Test Analog Outputs, and press **ENTER**. The Test Analog Output screen appears as shown below.

```
┌──────────────────────────────┐
│                              │
│  SET OUTPUTS TO:             │
│  >ZERO                       │
│   FULL SCALE                 │
│   RAMP                       │
│                              │
└──────────────────────────────┘
```

Test Analog Outputs Menu

4. Press **ENTER** to select Zero. The zero screen appears as shown below. Using a small screwdriver, adjust potentiometer R1 and R3 on the D/A Board until the analog outputs read 0 volts. Press the **MENU** pushbutton to return to the Test Analog Outputs menu.

```
┌──────────────────────────────┐
│                              │
│                              │
│  OUTPUTS         0.0 %       │
│                              │
│  ↑↓ INC/DEC                  │
│                              │
└──────────────────────────────┘
```

Zero Analog Outputs Screen

5. Press the ↓ pushbutton to move the cursor to Fullscale and press **ENTER**. The fullscale screen appears as shown below. Using a small screwdriver, adjust potentiometer R2 and R4 on the D/A Board until the analog outputs read 10 volts (standard instrument). Press the **MENU** pushbutton to return to the Test Analog Outputs menu.

```
┌─────────────────────────────┐
│                             │
│  OUTPUTS        100.0 %      │
│                             │
│  ↑↓ INC/DEC                  │
│                             │
└─────────────────────────────┘
```
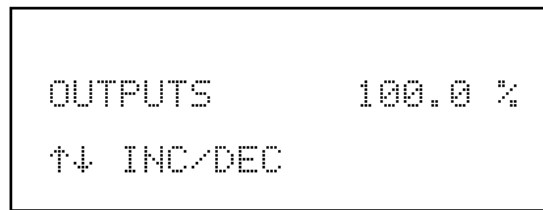
Fullscale Analog Outputs Screen

6. Repeat the above steps to ensure the adjustments are accurate.
7. Re-install the instrument cover.

PRESSURE TRANSDUCER ADJUSTMENT

This procedure should only be performed by an instrument service technician.

Equipment Required:
    Vacuum Pump
    Screwdriver

CAUTION: Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

---

1. Wear an antistatic wrist strap that is properly connected to earth ground, see "Safety Precautions," earlier in this chapter for more information.
2. Remove the instrument cover.
3. Disconnect the tubing from the pressure transducer and connect a vacuum pump known to produce a vacuum less than 1 mm Hg.
4. From the Run screen, press **MENU** to display the Main Menu. Use the ↓ pushbutton to move the cursor to Instrument Control. Press **ENTER** to display the Instrument Control menu. Use the ↓ pushbutton to move the cursor to Pressure Correction. Press **ENTER** to display the pressure reading.
5. Adjust the zero potentiometer on the pressure transducer for a reading of zero mm Hg.
6. Disconnect the vacuum pump. The display should read the current local barometric pressure. If this value does not agree with a known accurate barometer, adjust the span potentiometer.
7. Re-install the instrument cover.

An error in the zero setting of the pressure transducer does not introduce a measurable error in the output concentration reading. Therefore, if only a barometer is available and not a vacuum pump, only adjust the span setting. A rough check of the pressure accuracy can be made by obtaining the current barometric pressure from the local weather station or airport and comparing it to the pressure reading. However, since these pressures are usually corrected to sea level, it may be necessary to correct the reading to local pressure by subtracting 0.027 mm Hg per foot of altitude. Do not try to calibrate the pressure transducer unless the pressure is known accurately.

TEMPERATURE SENSOR ADJUSTMENT

This procedure should only be performed by an instrument service technician.

Equipment Required:
    Calibrated Thermometer or 10K$\Omega \pm$ 1% Resistor
    Screwdriver

CAUTION: Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

---

1. Wear an antistatic wrist strap that is properly connected to earth ground, see "Safety Precautions," earlier in this chapter for more information.
2. Remove the instrument cover.
3. Tape the thermistor plugged into the Motherboard to a calibrated thermometer.
4. Adjust the **GAIN** potentiometer on the Analog to Digital Board until the internal temperature reading agrees with the value on the calibrated thermometer. Since the thermistors used in the Model 42C are interchangeable to an accuracy of $\pm$ 0.2°C, and have a value of 10K ohms at 25°C, an alternate procedure is to connect an accurately known 10K resistor to the thermistor input on the Motherboard, and adjust the **GAIN** potentiometer for an internal temperature reading of 25°C. Note that a 1°C change corresponds to a $\pm$ 5% change in resistance, thus this alternative procedure can be quite accurate as a check; however, it clearly is not NIST traceable.

5. Re-install the instrument cover.

PMT HIGH VOLTAGE POWER SUPPLY ADJUSTMENT

Use the following procedure to adjust the PMT High Voltage Power Supply after switching from standard to extended ranges or vice versa. This procedure should only be performed by an instrument service technician.

CAUTION: Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

---

1. Wear an antistatic wrist strap that is properly connected to earth ground, see "Safety Precautions," earlier in this chapter for more information.
2. Remove the instrument cover.
3. Set option switch 7 on for extended ranges, or off for standard ranges.
4. Select new NO, NO_2, and NO_x ranges.
5. Set calibration factors NO BKG and NO_x BKG to 0.0. Set calibration factors NO COEF, NO_x COEF, and NO_2 COEF to 1.000.
6. Set the averaging time to 10 seconds.
7. Allow the instrument to sample calibration gas until a stable reading is obtained.
8. Adjust the PMT High Voltage Power Supply potentiometer (this is the potentiometer located on the top of the PMT High Voltage Power Supply) so that the instrument reads the calibration gas.
9. Perform an instrument calibration. For more information about calibration, see Chapter 4, "Calibraton."
10. Re-install the instrument cover.

FUSE REPLACEMENT

Equipment Required:
    115V T, 3A, 250V
    220V T, 1.6A, 250V

1. Disconnect power to instrument.
2. Remove fuse drawer, located on the AC power connector.
3. Replace both fuses, if either is blown.
4. Insert fuse drawer and reconnect power cord.

REPLACING THE AMMONIA SCRUBBER

- Flat head screwdriver
- Screw holder (approximately 10")
- Two 7/16" wrenches
- 9/16" wrench

Use this procedure to replace the ammonia scrubber:

1. Remove the instrument cover.
2. To replace the ammonia scrubber, it might be necessary to re-position the converter as described in the steps below:
   a. Using the 9/16" wrench, loosen and separate the two fittings connecting the reaction chamber and switching valve/pressure transducer to the converter.
   b. Disconnect the fitting located on either end of the converter. The fittings should be removed by unscrewing the nuts indicated by the arrows.
   c. Remove the four screws at the base of the converter.
   d. Remove the converter from the instrument without disconnecting any of the leads to the circuit board and place the converter to the side of the analyzer.
3. Remove all clamps or tie-wraps securing the ammonia scrubber in place.
4. Unscrew the Teflon tubing at both ends of the ammonia scrubber.
5. Using the attached fittings, replace the ammonia scrubber so that one end is plumbed to the outlet of the sample capillary and the second end is attached to the tubing running to the common port of the NO/NOx switching valve. Note the location of the ammonia scrubber between the PMT housing and the divider panel.
6. Replace all clamps or tie-wraps and secure the ammonia scrubber in place.
7. Return the converter to its original position and tighten all fittings.
8. Replace the instrument cover.

SERVICE LOCATIONS

For additional assistance, Environmental Instruments Division has service available from exclusive distributors worldwide. Contact one of the phone numbers below for product support and technical information.

866-282-0430 Toll Free
508-520-0430 International

CHAPTER 8
THEORY OF OPERATION

In order to understand the operation of the Model 42C, a general knowledge of the electronics, software, and subassemblies is necessary.

ELECTRONICS

The electronics can be broken down into the following subassemblies:

- DC Power Supply
- Photomultiplier Tube Power Supply
- Ozonator Power Supply
- Temperature Control Board
- Input Board
- Microprocessor System

A brief description of each follows. Note that all the electrical schematics are given in Appendix D, "Schematics."

DC Power Supply

The DC Power Supply outputs the regulated and unregulated dc voltages necessary to operate the digital electronics, Input Board, and the Temperature Control Board. It outputs +24 volts unregulated and ±15 volts and +5 volts regulated. The DC Power Supply Board also contains the circuitry for driving the solenoid valves and a circuit for powering and controlling the photomultiplier cooler supply.

Photomultiplier Tube Power Supply

The Photomultiplier Tube (PMT) Power Supply provides the PMT with the negative high voltage required for operation. The power supply output may be adjusted from about -500 to -1300 volts dc.

Ozonator Power Supply

The Ozonator Power Supply provides the ozone transformer with approximately 55 Hz, 15 volt pulses which the transformer steps up to about 15 kilovolts. The timer, U5, generates a square wave which feeds U3. This IC generates pulses which feed the network composed of U2, C2, C3, R4 and R5. This network acts to turn Q1 and Q2 on and off in a 4-step cycle. This cycle results in the discharge of C1 and C5 through the transformer generating high voltage pulses which power the silent-discharge ozonator.

Temperature Control Board

The Temperature Control Board regulates and sets the temperature of the converter and the reaction chamber. The converter temperature is measured with a type K thermocouple. The thermocouple voltage is conditioned by U4, which supplies a voltage output of 10 mV per °C. The conditioned signal is compared to a reference signal set by a potentiometer, and the comparator output is used to turn the heating element on and off. Both the converter set temperature and the conditioned thermocouple signal are picked up by the microprocessor and are used to display the actual converter temperature, as well as the converter set point.

The reaction chamber temperature is measured with a thermistor, whose resistance is equal to that of the reference resistor at approximately 50°C. The voltage across the thermistor is used by the microprocessor system for use in calculating and displaying the reaction chamber temperature.

Input Board

The Input Board accepts the current signal from the PMT and converts it to a voltage through a 100 megohm feedback resistor (R10). This voltage is scaled by about a factor of 1, 10, or 100, depending on the fullscale range of the NO channel. The scaled voltage signal is converted to a pulse train by the V/F converter and sent to the microprocessor.

A switch on the Input Board turns a test signal on and off which is injected at the first stage of the Input Board in parallel with the PMT input. This allows the Input Board and the connection to the processor system to be tested without using the PMT.

The Microprocessor System

The microprocessor system consists of printed circuit boards which plug into the Motherboard, connecting them to each other and to the rest of the instrument. These boards are as follows:

- Display Module
- Processor Board
- Digital to Analog Board
- Analog to Digital Board
- C-Link Board

Display Module. The vacuum fluorescent display module shows NO, NO_2, and NO_x concentrations, instrument parameters, and help messages. The single board display module consists of 80 characters (4 line by 20 column), refresh memory, character generator, dc/dc converter and all necessary control logic. The display module is powered by +5 volts dc.

Processor Board.   The Processor Board contains a Motorola M68HC11F1 microprocessor (U4), RAM (U5), and EPROM (U2). In addition, this high-performance, nonmultiplexed 68-pin microprocessor contains 512 bytes of EEPROM and 1K of RAM. It is operated at a frequency of 2 MHz, which is generated by crystal X1.

During each instruction cycle, the processor fetches an instruction from memory and executes it, reading or writing data to or from the data bus, or performing a calculation on some internal register or registers. The reset signal is generated by U8. This signal resets the M68HC11F1 every tenth of a second, and is used by the microprocessor to keep track of time. Each time the microprocessor is reset, it reads the counters, increments the clock, checks the status of the pushbuttons, and updates the D/A converters and display. The MC64B40 counter chip (U1) acts as the interface between the Input Board and the microprocessor. A pulse train from the Input Signal Board is directly fed into one of three counters on the MC64B40 counter chip.

Digital/Analog Board. The Digital to Analog Board contains four D/A converters, one for each analog output. Each is addressed by the processor via signals from PA0-PA7 and PG0 and PG1. The D/A converters are zeroed using potentiometers R1, R3, R5, and R7 and span is set using potentiometers R2, R4, R6, and R8. The fullscale output of the four D/A converters is set by jumpers on switches SW1-SW4 on the D/A board. Fullscale voltages of 10, 5, 1, and 0.1 volts are available.

Analog to Digital Board. The Analog to Digital Board acts as an interface between all the signals monitored by the processor system and the microprocessor itself. Up to 12 analog inputs are available. The cooler temperature, reaction chamber temperature, internal temperature, pressure, power supply voltages, PMT high voltage, and flow rates are examples of analog signals converted to digital signals used by the microprocessor.

C-Link Board. The C-Link Board contains the RS-232 circuitry, clock, and memory for the datalogger. Incoming RS-232 signals are converted to TTL levels by U3, an RS-232 driver/receiver. The TTL signals are then interpreted by U5, a 68HC11 microprocessor, which is dedicated to remote communications. Data records from the internal datalogger are stored in U2, a 128K RAM, and the link program is stored in U6, a 64K EPROM. U10 is the internal clock. A battery supplies +5 volts to the clock and the data logger memory when instrument power off.

SOFTWARE

The software tasks of the processor can be broken down into four areas:

Instrument Control

Sixteen control lines are located on the Analog to Digital Board. Line 0 is used to turn the ozonator on or off. Lines 1, 2, 3, 4, and 5 go to the Power Supply Board and control the NO/NO$_x$ solenoid, zero/span solenoid, the sample/calibrate solenoid and any additional solenoids used for special applications. Line 6 is used to turn the PMT voltage on or off. Lines 13 and 15 go to the Input Board and control the gain of the preamplifier. The remaining lines are currently not in use.

Monitoring Signals

The monitoring of signals is tied to the tenth of a second cycle time for the processor system, and to the one and ten second intervals which are derived from this cycle time. Every tenth of a second, the processor is reset and the counters and pushbuttons are read. Once every second, the accumulated counts are sampled. The 1-second accumulated counts representing the NO/NO$_x$ are further accumulated for a total of 7 seconds before they are processed, while the other 1-second accumulated counts representing other signals are processed directly. Every ten seconds, the NO/NO$_x$ solenoid switches and the processor waits 3 seconds for the reaction chamber to flush and stabilize. After those 3 seconds, it samples the signal intensity for 7 seconds before again switching the solenoid.

Instrument Calculations

The calculation of the NO and NO_x concentrations is lengthy and uses the processor to provide the most accurate readings. The calculation begins by subtracting the appropriate electronic offset from the 7-second count accumulation. Following this correction, the raw accumulated counts are scaled according to the gain setting of the Input Board.

Next, the uncorrected NO and NO_x values are determined according to a unique averaging algorithm which minimizes errors resulting from rapidly changing gas concentrations. This algorithm results in NO and NO_x values which are stored in RAM in a circular buffer that holds all the 10 second data from the previous 5 minutes. This data is averaged over the selected time interval, which can be any multiple of ten between 10 and 300 (the manual mode has additional intervals of 1, 2, and 5 seconds). The background values for NO and NO_x, which are corrected for temperature, are subtracted from their respective averages. The NO reading is corrected by the stored span factor and by the temperature factor. The NO_x reading is partially corrected by the span factor, temperature factor, and balance factor. The corrected NO value is subtracted from the partially corrected NO_x value to yield an uncorrected NO_2 value. The NO_2 value is then corrected for converter efficiency to give a corrected NO_2 reading. Finally, the corrected NO_2 reading is added to the corrected NO reading to yield a fully corrected NO_x value.

Output Communication

The front panel display and analog outputs are the primary means of communicating the result of the above calculations. The front panel display presents the NO, NO_2, and NO_x concentrations simultaneously. The display is updated every 10 seconds.

The analog outputs do vary according to the range. They are calculated by dividing the data values by the fullscale range for each of the three parameters and then multiplying each result by 1000. Negative concentrations can be represented as long as they are within -2.3% of fullscale. This gives numbers between -23 and 1000, which are used to drive the four digital to analog converters.

SUBASSEMBLIES

Photomultiplier Cooler

The thermoelectric cooler houses the PMT. The PMT is of the multi-alkali type in order to have the infrared sensitivity required to detect NO_2 luminescence. The PMT is cooled to about -3°C to reduce dark current and increase instrument sensitivity. The cooler is also controlled at this temperature in order to have increased zero and span stability over a wide ambient temperature range.

Reaction Chamber

The reaction chamber subassembly is an integral part of the cooler assembly. It is a two-piece 24 carat gold plated assembly which design allows for ease of cleaning and maintenance. In this reaction chamber, the sample reacts with ozone, producing excited NO_2 which in turn decays, giving off a photon of energy. The reaction chamber is heated and controlled to approximately 50°C in order to ensure the greatest instrument stability. Also housed in the reaction chamber assembly are the sample and ozone flow capillaries and a thermistor sensor.

NO_2-to-NO Converter

The NO_2-to NO converter employs molybdenum heated to approximately 325°C in order to convert and detect NO_2. The converter consists of an insulated housing, heater, replaceable cartridge, and a type K thermocouple sensor.

CHAPTER 9
OPTIONAL EQUIPMENT

This chapter describes optional equipment available for the Model 42C.

LAG VOLUME OPTION (500)

Principle of Operation

The Model 42C is based on the principle that nitric oxide (NO) and ozone react to produce a characteristic luminescence with an intensity linearly proportional to the NO concentration. Infrared light emission results when electronically excited NO_2 molecules decay to lower energy states. Specifically,

$$NO + O_3 \rightarrow NO_2 + O_2 + h\nu$$

Nitrogen dioxide (NO_2) must first be transformed into NO before it can be measured using the chemiluminescent reaction. NO_2 is converted to NO by a molybdenum NO_2-to-NO converter heated to about 325°C.

$$3\,NO_2 + Mo \rightarrow 3\,NO + MoO_3$$
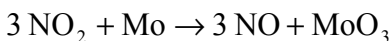
The ambient air sample enters the Model 42C through an inline Teflon® particulate filter, through a flow control capillary, and then splits between the NO and the NO_x channel. In the NO channel, the spilt sample is directed to the common port of the three-way solenoid valve. The sample is then routed either to the inlet tee of the reaction chamber or joins the exhaust of the reaction chamber. In the NO_x channel, the split sample is directed to the common port of a second three-way solenoid valve after having passed through the NO_2 converter and a lag volume, as shown if Figure 9-1. The "delayed" sample is then routed identically to the NO channel.

The two channels operate 180° out of phase, that is, when the instrument is monitoring NO, the NO_x sample is being bypassed, and when the instrument is monitoring NO_x, the NO sample is being bypassed. The solenoids switch every 5 seconds and the size of the lag volume has been chosen so the same original sample is being monitored by both the NO and the NO_x channels. In this way, any positive or negative errors in the NO_2 signal (determined by the difference between the NO_x and NO readings) is minimized - especially in a situation where the sample is changing rapidly, e.g., an urban traffic environment.

The Model 42C stores the NO signal obtained during the first half of the solenoid cycle, determines the NO_x signal during the second half of the solenoid cycle, and then calculates and updates a NO, NO_z, and NO_x signal every 10 seconds. Averages are available then from 10 to 300 seconds.
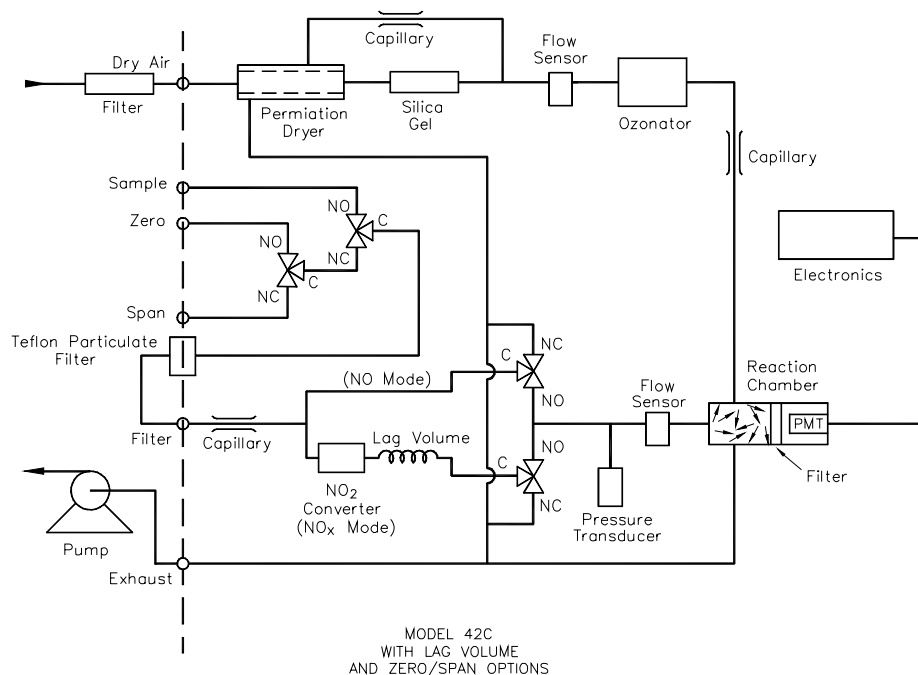
Figure 9-1. Flow Diagram, Lag Volume Option 500

To calibrate the Model 42C with lag volume option, follow the procedure below:

1. Set the NO range to 1,000 ppb and the averaging time to 10 seconds.

2. Introduce approximately 800 ppb NO into the Model 42C. Wait for a stable reading and then record the NO_2 reading. Next, introduce zero air into the Model 42C. Wait until the instrument reads close to zero (<3 ppb). Repeat the above procedure two more times. Take the average of the three NO_2 readings. The average NO_2 reading should be less than 50 ppb.

RACK MOUNTS WITH SLIDES

Rack mounts with slides for standard 19-inch relay racks are available. Figures 9-2 and 9-3 illustrate the installation of the rack mount option. Also available, as Option 209, are the handle mounting brackets and handles without the rack mounts.
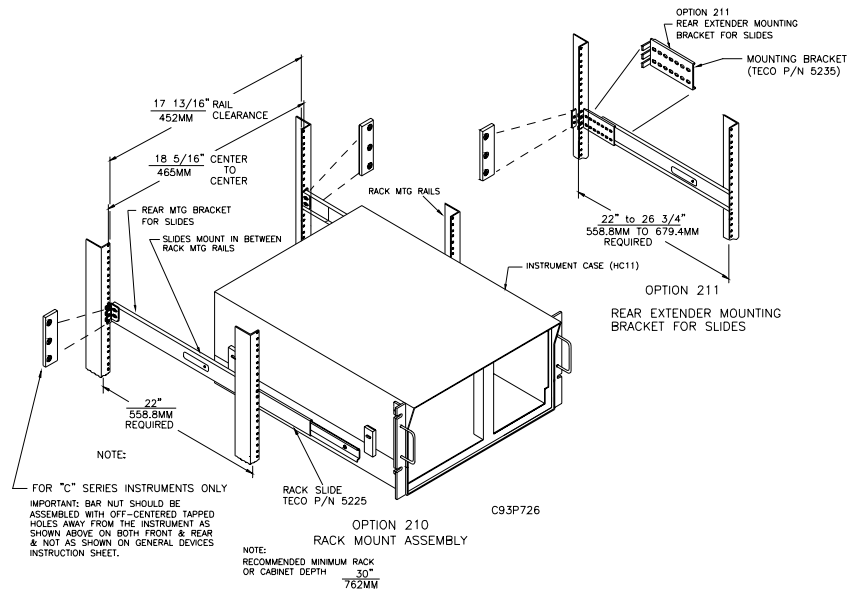
Figure 9-2. Rack Mount Option Assembly
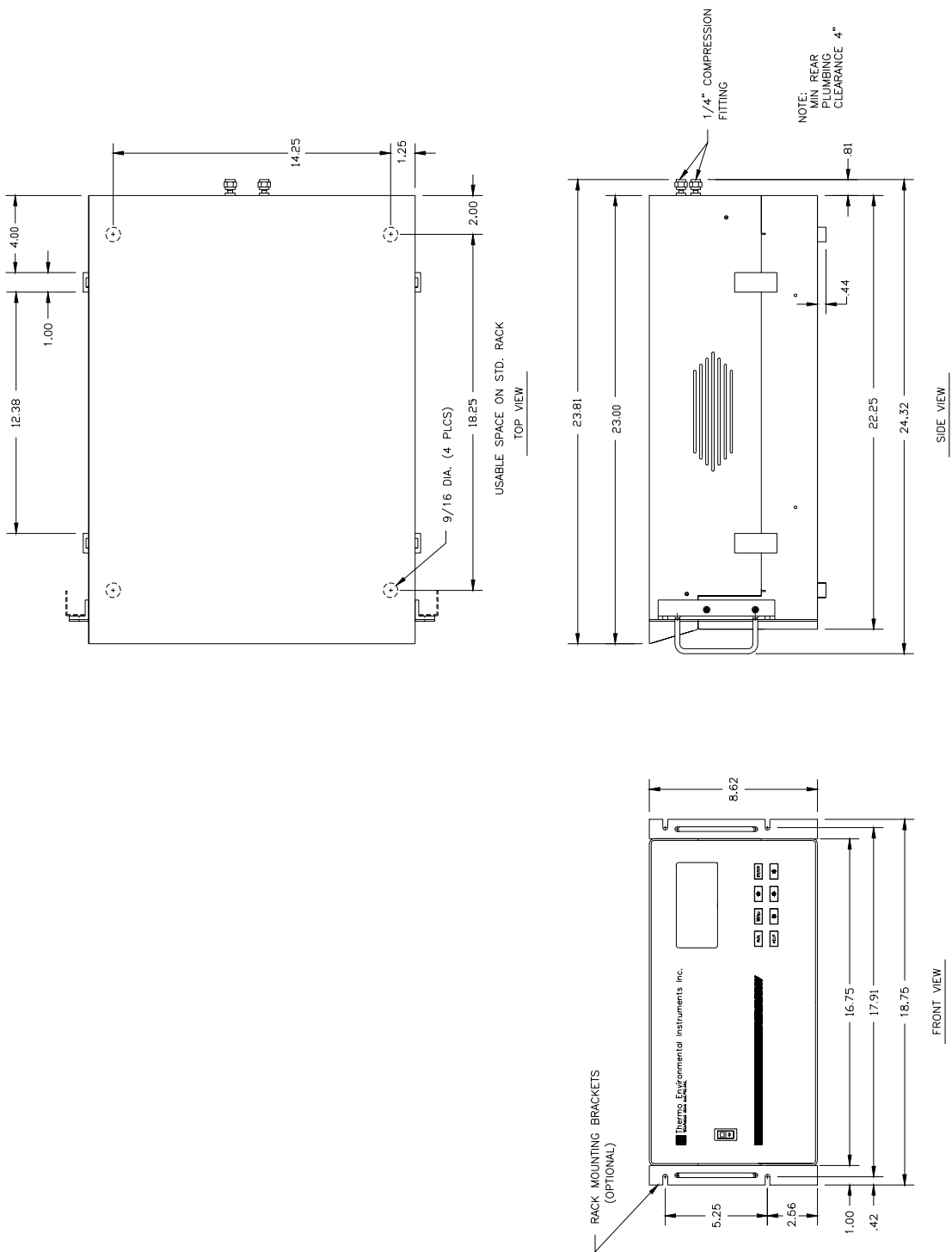
Figure 9-3. Model 42C Dimensional Outline

INTERNAL ZERO/SPAN AND SAMPLE VALVES

With the zero/span valve option, a source of span gas is connected to the **SPAN** port and a source of zero air is connected to the **ZERO** port as shown in Figure 9-4. Zero and span gas should be supplied at atmospheric pressure. It may be necessary to use an atmospheric dump bypass plumbing arrangement to accomplish this. For more information, refer to Chapter 2, "Installation." If this option is installed, option switch 3 must be on. For more information, refer to Chapter 3, "Operation."
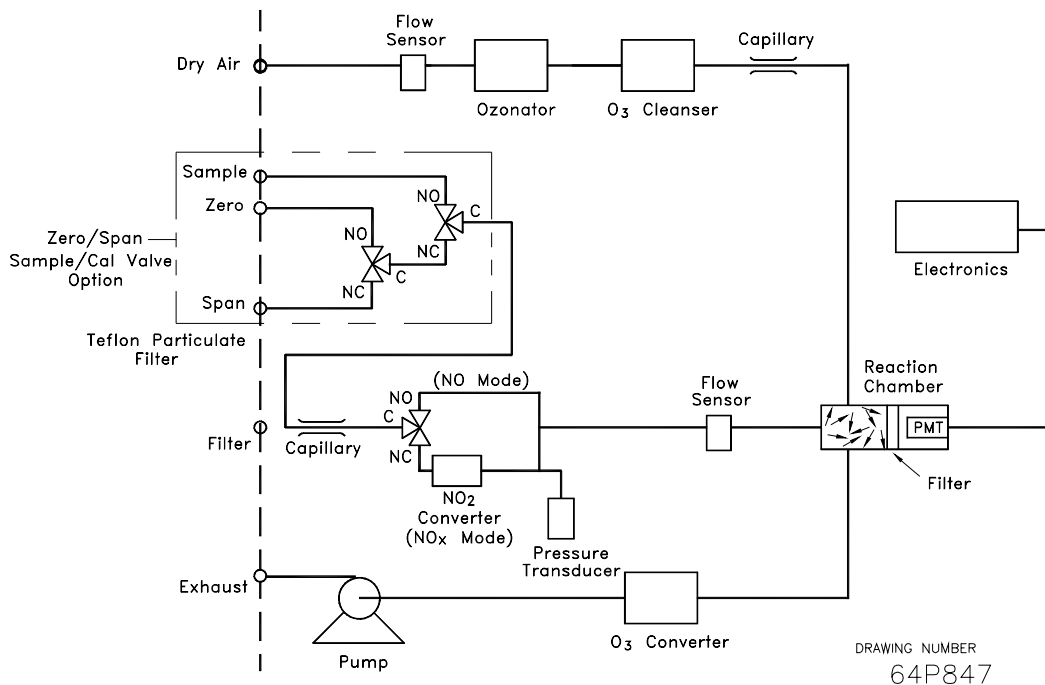
Figure 9-4. Flow Diagram, Zero/Span Option 300

Use the **RUN** pushbutton while in the Run screen to manually switch the valves between sample, zero, and span. The active mode is shown in the lower left-hand corner of the display as shown below.


```
NO  PPB              62.7
NO2 PPB              25.5
NOx PPB              88.2
SAMPLE 10:25
```
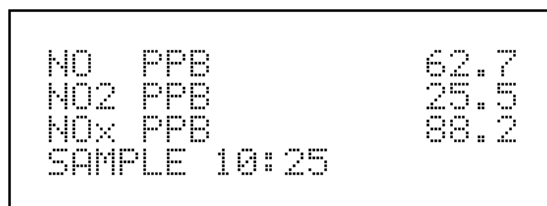
Run Screen in Sample Mode

Zero/Span Check

Automatic zero/span checking is available in the local mode (option switch 1 off) with the zero/span valve option. Zero/Span Check appears in the Calibration screen as shown below. Use the ↓ pushbutton to move the cursor to Zero/Span Check and press **ENTER**.

```
CALIBRATION:
>CALIBRATE NO   BKG
 CALIBRATE NOx BKG
 CALIBRATE NO

 CALIBRATE NOx
 CALIBRATE NO2
 CALIBRATE PRESSURE
 ZERO/SPAN CHECK
```

Calibration Screen with Zero/Span Check

The Zero/Span Check menu appears as shown below.

```
ZERO/SPAN CHECK:
>NEXT DATE  01/15/95
 NEXT TIME     12:00
 PERIOD HRS       24

 Z DURATION MIN   15
 S DURATION MIN   15
```

Zero/Span Check Menu

To set zero/span check, follow the procedure below:

1. Set the date of the first zero/span check. The Next Date screen, shown below, is used to set the initial date of the zero/span check. Once the initial zero/span check is performed, the date of the next zero/span check is calculated and displayed.

```
┌─────────────────────────────────┐
│  START DATE 01/01/95            │
│  SET TO     01/02/95?           │
│                                 │
│  ↑↓ INC/DEC ↔ CURSOR            │
└─────────────────────────────────┘
```

Start Date Screen

2. Set the time of the first zero/span check. The Next Time screen, shown below, is used to set the initial time of the zero/span check. Once the initial zero/span check is performed, the time of the next zero/span check is calculated and displayed.

```
┌─────────────────────────────────┐
│  START DATE    12:00            │
│  SET TO        13:00?           │
│                                 │
│  ↑↓ INC/DEC ↔ CURSOR            │
└─────────────────────────────────┘
```

Start Time Screen

3. Set the period between zero/span checks. The Period screen, shown below, defines the period or interval between zero/span checks. Periods between 2 and 1,000 hours are acceptable. To turn the zero/span check off, set the period to 0.

```
┌─────────────────────────────────┐
│  PERIOD        24 HRS           │
│  SET TO        25 HRS?          │
│                                 │
│  ↑↓ INC/DEC                     │
└─────────────────────────────────┘
```

Period Screen

4. Set the zero check and the span check duration. The Z (zero) Duration screen, shown below, defines how long zero air is sampled by the instrument. The S (span) Duration screen looks and functions the same way as the Z Duration screen, and is used to set how long the span gas is sampled by the instrument. Durations between 1 and 60 minutes are acceptable. Each time a zero/span check occurs the zero check is done first, followed by the span check. To perform just a zero check, set the S Duration screen to 0. To perform just a span check, set the Z duration screen to 0.

```
 ┌─────────────────────────────┐
 │                             │
 │  Z DURATION    30 MIN       │
 │  SET TO        31 MIN?      │
 │                             │
 │  ↑↓ INC/DEC                 │
 │                             │
 └─────────────────────────────┘
```
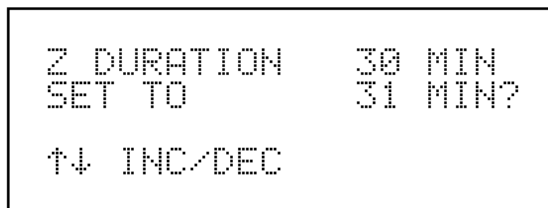
Z Duration Screen

REMOTE ACTIVATION OF ZERO/SPAN AND SAMPLE VALVES

The rear panel I/O (DB25) connector, shown in Figure 9-5, enables the zero/span and sample valves to be remotely controlled via contact closure. In addition, the connector has several instrument status outputs. Option switch 1 must be on and option switch 2 off in order to enable the remote I/O connector.
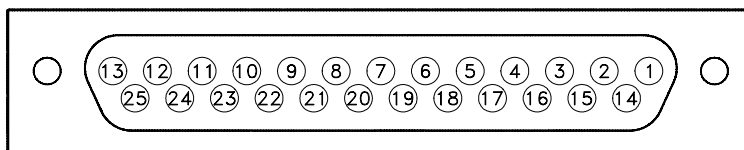
Pin Out

(1) Ground
(2) NC
(3) NC
(4) INPUT – N0 Measure Mode
(5) INPUT - Zero Gas
(6) Ground
(7) Relay Common
(8) STATUS - Concentration Alarm
(9) STATUS - Local or Remote Mode
(10) STATUS - ppm or mg/m3 mode
(11) STATUS - General Alarm
(12) Relay Common

(13) NC
(14) Ground
(15) NC
(16) NC
(17) INPUT – NO_x Measure Mode
(18) INPUT - Span Gas
(19) Ground
(20) Relay Common
(21) STATUS - Zero Gas Mode
(22) STATUS - Span Gas Mode
(23) NO Measure Mode
(24) NO_x Measure Mode
(25) Relay Common

Figure 9-5. Rear Panel I/O Connector   64P947-5

Input Pins

To activate the zero gas mode, connect pin 1, 6, 14, or 19 (ground) to pin 5 (zero gas mode), as shown in Figure 9-6. To deactivate the zero gas mode, disconnect ground from the zero gas mode input.
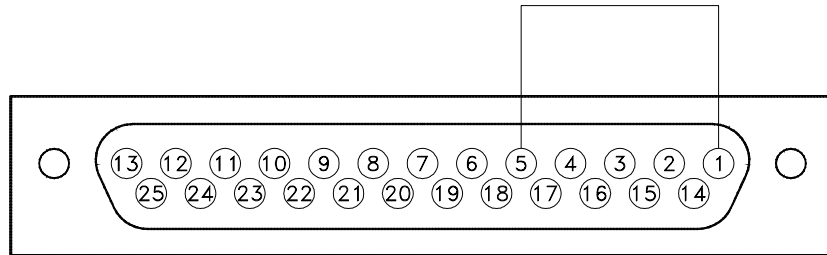
Figure 9-6. Remote I/O Zero Gas Mode Activation   64P947-6

To activate the span gas mode, connect pin 1, 6, 14, or 19 (ground) to pin 18 (span gas mode), as shown in Figure 9-7. To deactivate the span gas mode, disconnect ground from the span gas mode input.
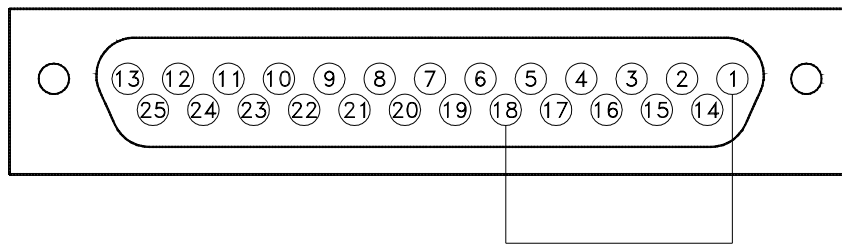
Figure 9-7. Remote I/O Span Gas Mode Activation   64P947-7

To activate the NO measure mode, connect pin 1, 6, 14, or 19 (ground) to pin 4 (NO measure mode), as shown in Figure: 9-8. To deactivate the NO measure mode, disconnect ground from the NO measure mode input.
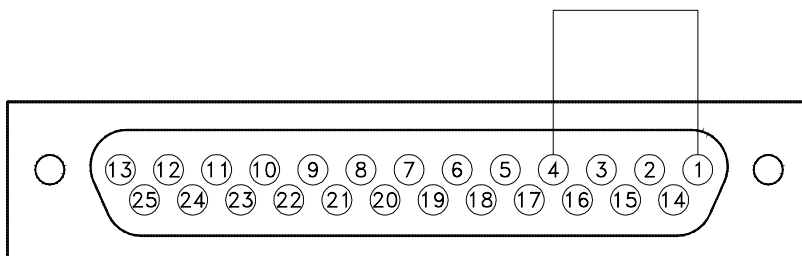
Figure 9-8. Remote I/O NO Measure Mode Activation   64P947-9

To activate the NO_x measure mode, connect pin 1, 6, 14, or 19 (ground) to pin 17 (NO_x measure mode), as shown in Figure 9-9. To deactivate the NO_x measure mode, disconnect ground from the NO_x measure mode input.
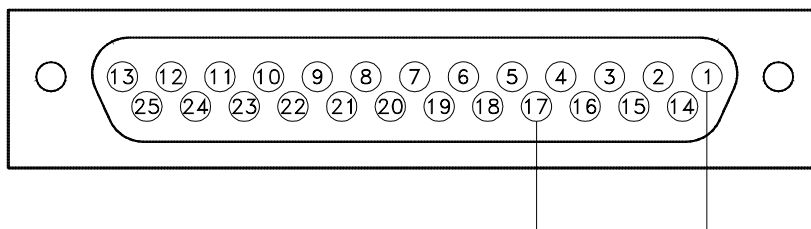
Figure 9-9. Remote I/O NO_x Measure Mode Activation   64P947-10

Instrument Status Outputs

Several instrument status outputs are available on the rear panel I/O (DB25) connector via reed relays on the I/O Board. The reed relays are arranged as shown in Figure 9-10. In the instrument status output truth tables, each pin is referred to as open or closed (based on the physical position of the corresponding relay) as shown in Table 9-1. The Relay Common line is common to each of the relays.
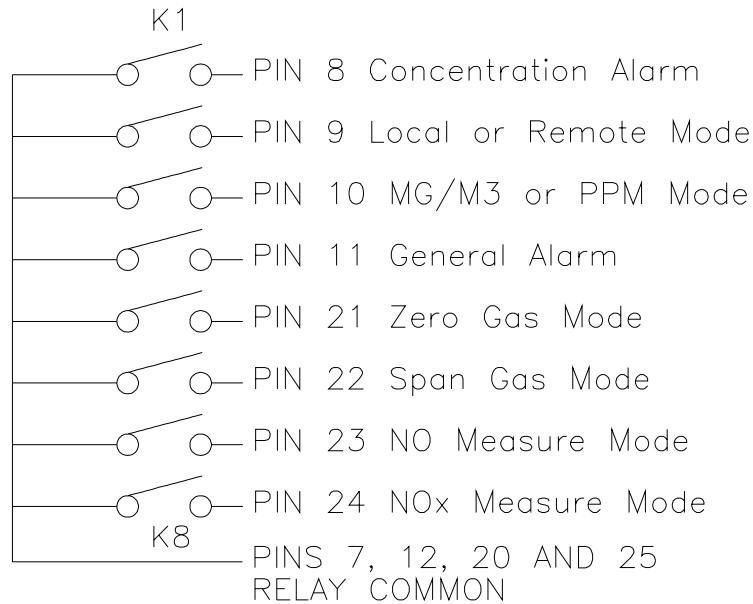
Figure 9-10. Instrument Status Output Relays

64P955

Table 9-1. Instrument Status Output Truth Table
If the relays are selected to be normally open then:

Status	Pin	Relay Closed	Relay Open
Concentration Alarm	8	Alarm	No Alarm
Local or Remote Mode	9	Local or Service Mode	Remote Mode
MG/M^3 or PPM Mode	10	mg/m^3 mode	ppm mode
General Alarm	11	Alarm	No Alarm
Zero Gas Mode Active	21	Zero Mode On	Zero Mode Off
Span Gas Mode Active	22	Span Mode On	Span Mode Off
NO Measure Mode	23	NO Measure Mode On	NO Measure Mode Off
NO$_x$ Measure Mode	24	NO$_x$ Measure Mode On	NO$_x$ Measure Mode Off

4-20 mA ISOLATED CURRENT OUTPUT

A 4-20 mA Isolated Current Output enables the NO, NO_2, and NO_x concentrations to be output at 4-20 mA as shown in the Table 9-2 and Figure 9-11.

Table 9-2. Output Number and Corresponding Concentration

Output Current Range Mode	Output #1	Output #2	Output #3	Output #4
Single	NO	NO_2	NOx	Unused
Dual	Low No_x	High NO_x	Low NO	High NO
Auto	NO	NO_2	NOx	Status high = 12 mA Status low = 4 mA
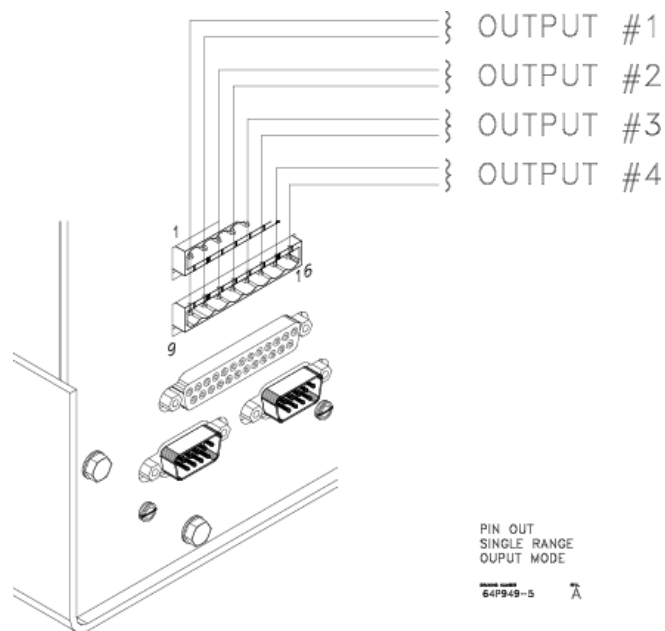
Figure 9-11. Pin-Out of Rear Panel Terminal Strip with Optional Current Output

OZONE PARTICULATE FILTER

The ozone particulate filter minimizes the potential for contamination of the ozonator by trapping any particulate matter before passing through the ozonator.

PERMEATION DRYER

With the permeation dryer option, it is not necessary to constantly replenish the ozonator air drying column as in the standard instrument. The permeation dryer provides a continuous stream of dry air to the ozonator (using the selective water permeation characteristics of the dryer), minimizing routine maintenance procedures.

INSTRUMENT HANDLE

An instrument handle is available to aid in carrying the instrument. It also enables the instrument to be slightly elevated, while resting on a table or bench, to increase visibility of the display. Figure 9-12 shows the installation of the instrument handle.
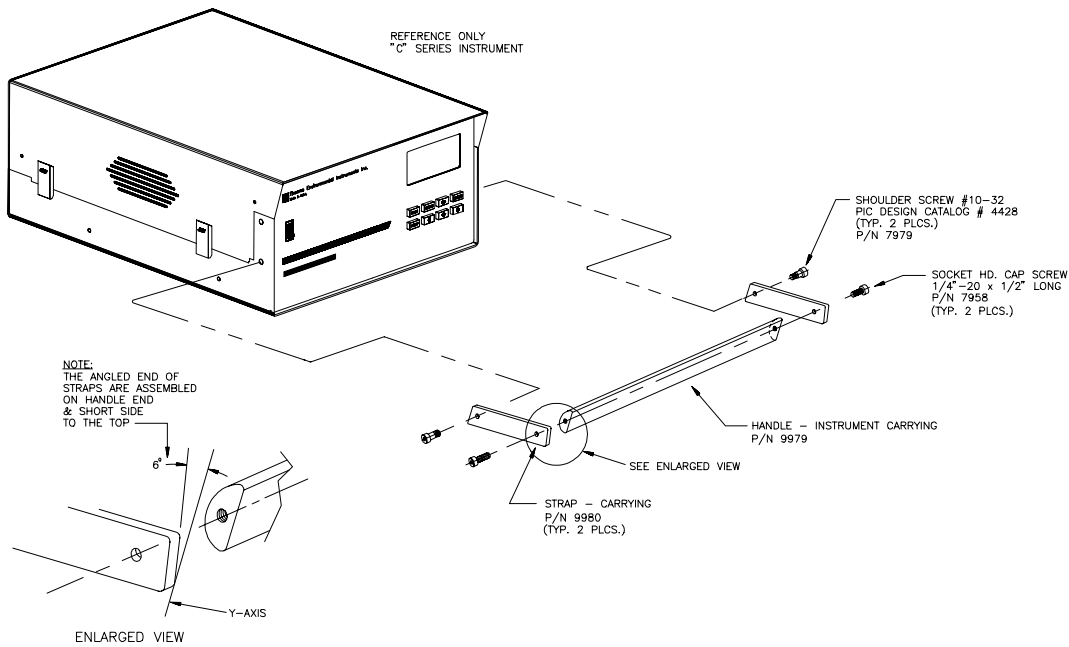
Figure 9-12. Instrument Handle Assembly   93P727

APPENDIX A
WARRANTY

Seller warrants that the Products will operate substantially in conformance with Seller's published specifications, when subjected to normal, proper and intended usage by properly trained personnel, for 13 months from date of shipment or 12 months from date of installation, whichever is less (the "Warranty Period"). Seller agrees during the Warranty Period, provided it is promptly notified in writing upon the discovery of any defect and further provided that all costs of returning the defective Products to Seller are pre-paid by Buyer, to repair or replace, at Seller's option, defective Products so as to cause the same to operate in substantial conformance with said specifications. Replacement parts may be new or refurbished, at the election of Seller. All replaced parts shall become the property of Seller. Shipment to Buyer of repaired or replacement Products shall be made in accordance with the provisions of Section 5 above. Lamps, fuses, bulbs and other expendable items are expressly excluded from the warranty under this Section 8. Seller's sole liability with respect to equipment, materials, parts or software furnished to Seller by third party suppliers shall be limited to the assignment by Seller to Buyer of any such third party supplier's warranty, to the extent the same is assignable. In no event shall Seller have any obligation to make repairs, replacements or corrections required, in whole or in part, as the result of (i) normal wear and tear, (ii) accident, disaster or event of force majeure, (iii) misuse, fault or negligence of or by Buyer, (iv) use of the Products in a manner for which they were not designed, (v) causes external to the Products such as, but not limited to, power failure or electrical power surges, (vi) improper storage of the Products or (vii) use of the Products in combination with equipment or software not supplied by Seller. If Seller determines that Products for which Buyer has requested warranty services are not covered by the warranty hereunder, Buyer shall pay or reimburse Seller for all costs of investigating and responding to such request at Seller's then prevailing time and materials rates. If Seller provides repair services or replacement parts that are not covered by the warranty provided in this Section 8, Buyer shall pay Seller therefore at Seller's then prevailing time and materials rates. ANY INSTALLATION, MAINTENANCE, REPAIR, SERVICE, RELOCATION OR ALTERATION TO OR OF, OR OTHER TAMPERING WITH, THE PRODUCTS PERFORMED BY ANY PERSON OR ENTITY OTHER THAN SELLER WITHOUT SELLER'S PRIOR WRITTEN APPROVAL, OR ANY USE OF REPLACEMENT PARTS NOT SUPPLIED BY SELLER, SHALL IMMEDIATELY VOID AND CANCEL ALL WARRANTIES WITH RESPECT TO THE AFFECTED PRODUCTS.

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APPENDIX B
RS-232/485 COMMANDS

The RS-232/485 interface enables the analyzer to be controlled and interrogated by a remote device such as a PC, PLC, datalogger, etc. On the rear panel of the analyzer there are two male DB9 connectors. Both connectors are identical, so either can be connected to the remote device. The remaining connector can be used to connect a second analyzer. Using a daisy-chain configuration, several analyzers can be connected to one remote device.

RS-232 CONNECTION

A null modem (crossed) cable is required when connecting the analyzer to an IBM Compatible PC. However, a straight cable (one to one) may be required when connecting the analyzer to other remote devices. As a general rule, when the connector of the host remote device is female, a straight cable is required and when the connector is male, a null modem cable is required.

DATA FORMAT

    1200, 2400, 4800, or 9600 BAUD
    8 data bits
    1 stop bit
    no parity
    All responses are terminated with a carriage return (hex 0D)

RS-485 CONNECTION

The instrument uses a four wire RS-485 configuration with automatic flow control (SD). The pin configuration for DB9 connector on the rear of the instrument follows:

Pin# (DB9)	Function
4	+ receive
8	- receive
2	+ transmit
7	- transmit
5	ground

INSTRUMENT IDENTIFICATION NUMBER

Each command sent to the analyzer must begin with the ASCII symbol or byte value equivalent of the instrument's identification number plus 128. For example, if the instrument ID is set to 25, then each command must begin with the ACSII symbol (Ö) or byte value equivalent to decimal 153. The analyzer ignores any command that does not begin with its instrument identification number.

COMMANDS

The analyzer must be in the remote mode in order to change instrument parameters via remote. However, the command "set mode remote" can be sent to the analyzer to put it in the remote mode. Report commands can be issued either in the remote or local mode.

The Commands can be sent in either uppercase or lowercase characters. In the examples below, only the characters between the quotation marks ("") are sent and received. If an incorrect command is sent, a "bad cmd" message will be received. The example below sends the incorrect command "set time avg" instead of the correct "set avg time".

Send: "set time avg"
Receive: "set time avg bad cmd"

---

high no

This reports the NO concentration calculated with high coefficents. The example below shows that the high NO concentration is 22.91 ppb.

Send: "high no"
Receive: "high no 2291E-2 ppb"

---

low no

This reports the NO concentration calculated with low coefficients. The example below shows that the low NO concentration is 13.23 ppb.

Send: "low no"
Receive: "low no 1323E-2 ppb"

---

no

This reports the NO concentration when operating in single range or high NO when operating in dual or autorange. The example below shows that the NO concentration is 22.91 ppb.

Send: "no"
Receive: "no 2291E-2 ppb"

high no2

This reports the NO_2 concentration calculated with high coefficients. The example below shows that the high NO_2 concentration is 22.91 ppb.

Send: "high no2"
Receive: "high no2 2291E-2 ppb"

low no2

This reports the NO_2 concentration calculated with low coefficients. The example below shows that the low NO_2 concentration is 13.23 ppb.

Send: "low no2"
Receive: "low no2 1323E-2 ppb"

no2

This reports the NO_2 concentration when operating in single range or high NO_2 when operating in dual or autorange. The example below shows that the NO_2 concentration is 22.91 ppb.

Send: "no2"
Receive: "no2 2291E-2 ppb"

high nox

This reports the NO$_x$ concentration calculated with high coefficients. The example below shows that the high NO$_x$ concentration is 22.91 ppb.

Send: "high nox"
Receive: "hign nox 2291E-2 ppb"

low nox

This reports the NO$_x$ concentration calculated with low coefficients. The example below shows that the low NO$_x$ concentration is 13.23 ppb.

Send: "low nox"
Receive: "low nox 1323E-2 ppb"

nox
This reports the NO$_x$ concentration when operating in single range or high NO$_x$ when operating in dual or autorange. The example below shows that the low NO$_x$ concentration is 22.91 ppb.

Send: "nox"
Receive: "nox 2291E-2ppb"

gas mode

This reports the current mode of sample, zero, or span. The example below reports that the gas mode is sample.

Send: "gas mode"
Receive: "gas mode sample"

set sample

This command sets the zero/span valves to the sample mode. The example below sets the instrument to sample mode that is, the instrument is reading the sample gas.

Send: "set sample"
Receive: "set sample ok"

set zero

This command sets the zero/span valves to the zero mode. The example sets the instrument in the zero mode, that is, the instrument is sampling zero air.

Send: "set zero"
Receive: "set zero ok"

set span

This command sets the zero/span valves to the span mode. The example below sets the instrument to the span mode, that is, the instrument is sampling span gas.

Send: "set span"
Receive: "set span ok"

mode

This reports what operating mode the instrument is in: local, service, or remote. The example below shows that the instrument is in the remote mode.

Send: "mode"
Receive: "mode remote"

set mode local
set mode remote

These commands set the instrument to local or remote mode. The example below sets the instrument to the local mode.

Send: "set mode local"
Receive: "set mode local ok"

gas unit

This reports the current gas units (ppb, ppm, $\mu g/m^3$, or mg/m^3). The example reports that the gas unit is set to ppb.

Send: "gas unit"
Receive: "gas unit ppb"

set gas unit *unit*

unit = | ppb | ppm | ug/m3 | mg/m3 |

This command sets the gas units to ppb, ppm, $\mu g/m^3$, or mg/m^3. The example below sets the gas units $\mu g/m^3$.

Send: "set gas unit ug/m3"
Receive: "set gas unit ug/m3 ok"

range no
range no2
range nox

These commands report the current NO, NO_2, and NO_x ranges. The example below reports that the NO range is set to 50 ppb.

Send: "range no"
Receive: "range no 0: 5000E-2 ppb"

set range no *d*
set range no2 *d*
set range nox *d*

d = Code in table below

These commands select the NO, NO_2, and NO_x full-scale ranges according to the Tables below. The example below sets the NO_x full-scale range to 2,000 ppb.

Send: "set range nox 5"
Receive: "set range nox 5 ok"

---

low range no
low range no2
low range nox

These commands report the current NO, NO_2, and NO_x low ranges. The example below reports that the NO low range is set to 50 ppb.

Send: "low range no"
Receive: "low range no 0: 5000E-2 ppb"

---

set low range no *d*
set low range no2 *d*
set low range nox *d*

d = Code in table below

These commands select the NO, NO_2, and NO_x full-scale low ranges according to the tables below. The example below sets the NO_x full-scale low range to 2,000 ppb.

Send: "set range nox 5"
Receive: "set range nox 5 ok"

Standard Ranges:

Code	ppb	ppm	µg/m³	mg/m³
0	50	0.05	100	0.1
1	100	0.1	200	0.2
2	200	0.2	500	0.5
3	500	0.5	1,000	1.0
4	1,000	1.0	2,000	2.0
5	2,000	2.0	5,000	5.0
6	5,000	5.0	10,000	10.0
7	10,000	10.0	20,000	20.0
8	20,000	20.0	30,000	30.0
9	C1	C1	C1	C1
10	C2	C2	C2	C2
11	C3	C3	C3	C3

Extended Ranges:

Code	ppb	ppm	µg/m³	mg/m³
0	200	0.2	500	0.5
1	500	0.5	1,000	1.0
2	1,000	1.0	2,000	2.0
3	2,000	2.0	5,000	5.0
4	5,000	5.0	10,000	10.0
5	10,000	10.0	20,000	20.0
6	20,000	20.0	50,000	50.0
7	50,000	50.0	100,000	100.0
8	100,000	100.0	150,000	150.0
9	C1	C1	C1	C1
10	C2	C2	C2	C2
11	C3	C3	C3	C3

custom *d*

d = | 1 | 2 | 3 |

This reports the user-defined value of custom range 1, 2, or 3. The example below reports that custom range 1 is defined to 55.0 ppb.

Send: "custom 1"
Receive: "custom 1 5500E-2 ppb"

set custom 1 range *ddddd.d*
set custom 2 range *ddddd.d*
set custom 3 range *ddddd.d*

These commands are used to define three custom ranges. To use the custom range select it using the set range command. The example below sets custom range 1 to 55.5 ppb.

Send: "set custom 1 range 55.5"
Receive: "set custom 1 range 55.5 ok"

avg time

This reports the averaging time in seconds when operating in single range or averaging time in seconds used with the high range when operating in dual or autorange (same as high avg time). The example below shows that the average time is 300 seconds.

Send: "avg time"
Receive: "avg time 11: 300 sec"

high avg time

This reports the averaging time in seconds. The example below shows that the high averaging time is 300 seconds.

Send: "high avg time"
Receive: "high avg time 11: 300 sec"

low avg time

This reports the averaging time in seconds used with the low range. The example below shows that the low averaging time is 10 seconds.

Send: "low avg time"
Receive: "low avg time 3: 10 sec"

set avg time *d*

d = Code in table below

This sets averaging time and high averaging time, according to the Table below. The example below sets the averaging time to 60 seconds.

Send: "set avg time 6"
Receive: "set avg time 6 ok"

set low avg time *d*

In dual or autorange mode, this sets the low averaging time. The time code format is shown in the table below. The example below sets the low avg time to 120 seconds.

Send: "set low avg time 8"
Receive: "set low avg time 8 ok"

Code "D"	Time, NO Measure Mode, NOx Measure Mode	Time, NO/NOx Measure Mode
0	1 seconds	
1	2	
2	5	
3	10	10 seconds
4	20	20
5	30	30
6	60	60
7	90	90
8	120	120
9	180	180
10	240	240
11	300	300

no bkg
nox bkg

These commands report the current NO and NO_x backgrounds. The example below reports that the NO background is 5.5 ppb.

Send: "no bkg"
Receive: "no bkg 5.5 ppb"

set no bkg *dddd.d*
set nox bkg *dddd.d*

These commands are used to set NO and NO_x backgrounds to user-defined values. The example below sets the NO background to 5.5 ppb.

Send: "set no bkg 5.5"
Receive: "set no bkg 5.5 ok"

set cal no bkg

This command will auto calibrate the NO background. The example below shows a successful auto-calibration of the NO background.

Send: "set cal no bkg"
Receive: "set cal no bkg ok"

---

set cal nox bkg

This command will auto calibrate the NO_x background. The example below shows a successful auto-calibration of the NO_x background.

Send: "set cal nox bkg"
Receive: "set cal nox bkg ok"

---

no coef
no2 coef
nox coef

These commands report the current NO, NO_2, and NO_x coefficients. The example below reports that the NO coefficient is 1.005.

Send: "no coef"
Receive: "no coef 1.005"

---

set no coef *d.ddd*
set no2 coef *d.ddd*
set nox coef *d.ddd*

These command set the NO, NO_2 and NO_x coefficients to user-defined values. The example below sets the NO coefficient to 1.005.

Send: "set no coef 1.005"
Receive: "set no coef 1.005 ok"

low no coef
low no2 coef
low nox coef

These commands report the current low NO, NO_2, and NO_x coefficients. The example below reports that the low NO coefficient is 1.005.

Send: "low no coef"
Receive: "low no coef 1.005"

set low no coef *d.ddd*
set low no2 coef *d.ddd*
set low nox coef *d.ddd*

These command set the low NO, NO_2 and NO_x coefficients to user-defined values. The example below sets the low NO coefficient to 1.005.

Send: "set low no coef 1.005"
Receive: "set low no coef 1.005 ok"

set cal no coef

This command will auto calibrate the NO coefficient based on the NO span gas concentration. In dual or autorange mode, this is used to auto calibrate the high NO coefficient. The example below shows a successful auto-calibration of the NO coefficient.

Send: "set cal no coef"
Receive: "set cal no coef ok"

set cal low no coef

Used in dual and autorange, this command will auto calibrate the low NO coefficient based on the low NO span gas concentration. The example below shows a successful auto-calibration of the low NO coefficient.

Send: "set cal low no coef"
Receive: "set cal low no coef ok"

set cal no2 coef

This command will auto calibrate the NO_2 coefficient based on the NO_2 span gas concentration. In dual or autorange mode, this is used to auto calibrate the high NO_2 coefficient.   The example below shows a successful auto-calibration of the NO_2 coefficient.

Send: "set cal no2 coef"
Receive: "set cal no2 coef ok"

set cal low no2 coef

Used in dual or autorange, this command will auto calibrate the low NO_2 coefficient based on the low NO_2 span gas concentration. The example below shows a successful auto-calibration of the low no2 coefficient.

Send: "set cal low no2 coef"
Receive: "set cal low no2 coef ok"

set cal nox coef

This command will auto calibrate the NO_x coefficient based on the NO_x span gas concentration. In dual or autorange mode, this is used to auto calibrate the high NO_x coefficient. The example below shows that the machine cannot perform an auto-calibration because the calculated NO_x coefficient is too high.

Send: "set cal nox coef"
Receive: "set cal nox coef too high"

set cal low nox coef

Used in dual or autorange, this command will auto calibrate the low NO_x coefficient based on the low NO_x span gas concentration. The example below shows a successful auto-calibration of the low NO_x coefficient.

Send: "set cal low nox coef"
Receive: "set cal low nox coef ok"

no gas

This reports NO span gas concentration used to auto calibrate NO coefficient or the high NO coefficient when in dual or autorange. The example below shows that the NO span gas concentration is 3500.0 ppm.

Send: "no gas"
Receive: "no gas 3500E+0 ppm"

set no gas f

This sets the NO span gas concentration used by the auto calibration routine. When in dual or autorange, this applies to the high NO coefficient. The format is that of any legitimate floating point number. The gas units are the same as those chosen by the user. The example below sets the NO span gas concentration to 123.4 ppm.

Send: "set no gas 123.4"
Receive: "set no gas 123.4 ok"

low no gas

This reports low NO span gas concentration used to auto calibrate low NO coefficient when in dual or autorange. The example below shows that the NO low span gas concentration is 240.0 ppm.

Send: "low no gas"
Receive"   "low no gas 2400E-1 ppm"

set low no gas f

This sets the low NO span gas concentration used by the auto calibration routine. The format is that of any legitimate floating point number. The gas units are the same as those chosen by the user. The example below sets the NO low span gas concentration to 67.2 ppm.

Send: "set low no gas 67.2"
Receive: "set low no gas 67.2 ok"

no2 gas

This reports NO_2 span gas concentration used to auto calibrate NO_2 coefficient or the high NO_2 coefficient when in dual or autorange. The example below shows that the NO_2 span gas concentration is 2500.0 ppm.

Send: "no2 gas"
Receive: "no2 gas 2500E+0 ppm"

set no2 gas f

This sets the NO_2 span gas concentration used by the auto calibration routine. When in dual or autorange, this applies to the high NO_2 coefficient. The format is that of any legitimate floating point number. The gas units are the same as those chosen by the user. The example below set the NO_2 span gas concentration to 123.4 ppm.

Send: "set no2 gas 123.4"
Receive: "set no2 gas 123.4 ok"

low no2 gas

This reports low NO_2 span gas concentration used to auto calibrate low NO_2 coefficient when in dual or autorange. The example below shows that the NO_2 low span gas concentration is 140.0 ppm.

Send: "low no2 gas"
Receive: "low no2 gas 1400E-1 ppm"

set low no2 gas f

This sets the low NO_2 span gas concentration used by the auto calibration routine. The format is that of any legitimate floating point number. The gas units are the same as those chosen by the user. The example below set the NO2 low span gas concentration to 67.2 ppm.

Send: "set low no2 gas 67.2"
Receive: "set low no2 gas 67.2 ok"

nox gas

This reports NO_x span gas concentration used to auto calibrate NO_x coefficient or the high NO_x coefficient when in dual or autorange. The example below shows that NO_x span gas concentration is 4670.0 ppm

Send: "nox gas"
Receive: "nox gas 4670E+0 ppm"

set nox gas f

This sets the NO_x span gas concentration used by the auto calibration routine. When in dual or autorange, this applies to the high NO_x coefficient. The format is that of any legitimate floating point number. The gas units are the same as those chosen by the user. The example below sets the NO_x span gas concentration to 123.4 ppm.

Send: "set nox gas 123.4"
Receive: "set nox gas 123.4 ok"

low nox gas

This reports low NO_x span gas concentration used to auto calibrate low NO_x coefficient when in dual or autorange. The example below shows that the NO_x low span gas concentration is 421.0 ppm.

Send: "low nox gas"
Receive: "low nox gas 4210E-1 ppm"

set low nox gas f

This sets the low NOx span gas concentration used by the auto calibration routine. The format is that of any legitimate floating point number. The gas units are the same as those chosen by the user. The example below sets the NOx low span gas concentration to 67.2 ppm.

Send: "set low nox gas 67.2"
Receive: "set low nox gas 67.2 ok"

ozonator flow

This reports the current ozonator flow. The example below reports that the current ozonator flow is 0.050 liters/minute.

Send: "ozonator flow"
Receive: "ozonator flow 0.050 l/m"

---

ozonator status

This reports the status of the ozonator: on or off. The example below reports that the ozonator is off.

Send: "ozonator status"
Receive: if ozonator is set off receive: "ozonator status off"
               if ozonator is set on receive: "ozonator status off, ozonator set on" or
                                               "ozonator status on"

---

set ozonator on
set ozonator off

These commands turn the ozonator on and off. The example below turns the ozonator off.

Send: "set ozonator off"
Receive: "set ozonator off ok"

---

pmt voltage

This reports the current PMT voltage. The example below reports that the current PMT voltage is -818 volts.

Send: "pmt voltage"
Receive: "pmt voltage -818 volts"

---

pmt status

This reports the status of the PMT: on or off. The example below reports that the PMT is on.

Send: "pmt status"
Receive: "pmt status on"

set pmt on
set pmt off

These commands turn the PMT on and off. The example below turns the PMT off.

Send: "set pmt off"
Receive: "set pmt off ok"

meas mode

This reports which measurement mode (NO/NO_x, NO, or NO_x) is active. The example below reports that the measurement mode is set to NO.

Send: "meas mode"
Receive: "meas mode no"

set meas mode *mode*

mode = | no/nox | no | nox |

This command sets the instrument to the NO/NO_x (auto) mode, manual NO mode, or manual NO_x mode. The example below sets the instrument to the manual NO mode.

Send: "set meas mode no"
Receive: "set meas mode no ok"

internal temp

This reports the current internal instrument temperature. The example below shows that the internal temperature is 27.2°C.

Send: "internal temp"
Receive: "internal temp 27.2 deg C"

temp comp

This reports whether temperature compensation is on or off. The example below shows a typical response to this command.

Send: "temp comp"
Receive: "temp comp off"

set temp comp on
set temp comp off

This command turns the temperature compensation on and off. The example below turns temperature compensation off.

Send: "set temp comp off"
Receive: "set temp comp off ok"

react temp

This reports the current reaction chamber temperature. The example below reports that the current reaction chamber temperature is 49.9°C.

Send: "react temp"
Receive: "react temp 49.9 deg C"

conv temp

This reports the current NO_2 converter temperature. The example reports that the current converter temperature is 625°C.

Send: "conv temp"
Receive: "conv temp 625 deg C"

conv set temp

This command reports the temperature that the stainless steel converter is set to. The example below reports that the converter temperature is set to 625°C.

Send: "conv set temp"
Receive: "conv set temp 625 deg C"

pmt temp

This command reports the temperature of the PMT cooler. The example below reports that the PMT cooler temperature is -2.3°C.

Send: "pmt temp"
Receive: "pmt temp -2.3 deg C"

pres

This reports the current reaction chamber pressure. The example below shows that actual reaction chamber pressure is 240.2 mm Hg.

Send: "pres"
Receive: "pres 240.2 mm Hg"

pres comp

This reports whether pressure compensation is on or off. The example below shows that pressure compensation is on.

Send: "pres comp"
Receive: "pres comp on"

set pres comp on
set pres comp off

These commands turn the pressure compensation on and off. The example below turns pressure compensation off.

Send: "set pres comp off"
Receive: "set pres comp off ok"

pres cal

This reports the pressure recorded at the time of calibration. The example below shows that the pressure at calibration is 85.5 mm Hg.

Send: "pres cal"
Receive: "pres cal 85.5 mm Hg"

set pres cal *ddd.d*

This command set the calibration pressure to that specified by the user. The example below sets the calibration pressure to 120.5 mm Hg.

Send: "set pres cal 120.5"
Receive: "set pres cal 120.5 ok"

set cal pres

This command sets the current reactor pressure as the calibration pressure. The example below successfully sets the calibration pressure.

Send: "set cal pres"
Receive: "set cal pres ok"

relay stat

This returns the current relay status "open" or "closed". The example below shows that the status of the relays is normally open.

Send: "relay stat"
Receive: "relay stat open"

set relay open

This sets the relay logic to normally open. The example below sets the relay logic to normally open.

Send: "set relay open"
Receive: "set relay open ok"

set relay closed

This sets the relay logic to normally closed. The example below sets the relay logic to normally closed.

Send: "set relay closed"
Receive: "set relay closed ok"

time

This reports the current time (military time). The example below reports that the internal time is 2:15:30 pm.

Send: "time"
Receive: "time 14:15:30"

set time *hh:mm:ss*

hh = hours
mm = minutes
ss = seconds

Sets the internal clock (military time). The example below sets the internal time to 2:15 pm. Note that if seconds are omitted, the seconds default to 00.

Send: "set time 14:15"
Receive: "set time 14:15 ok"

date

This reports the current date. The example below reports the date as December 1, 1994.

Send: "date"
Receive: "date 12-01-94"

set date *mm-dd-yy*

mm = month
dd = day
yy = year

Sets the internal date. The example below sets the internal date to December 1, 1994.

Send: "set date 12-01-94"
Receive: "set date 12-01-94 ok"

dtoa *d*

d = DTOA in table below

This reports the outputs of the 8 Digital to Analog converters (0000 = 0.0% FS, 1000 = 100.0% fullscale). The example below shows that the D/A #1 is 97.7% fullscale.

Send: "dtoa 1"
Receive: "dtoa 1 97.7%"

option switches

This reports the status (on/off) of the 8 option switches. For example, a return of 10100000, means that option switches 1 and 3 are on and the others are off (see the Model 42C manual for option switch designation). The example below shows that only option switches 1 and 3 are on.

Send: "option switches"
Receive: "option switches 10100000"

program no

This reports the analyzer's program number and the Link (communication) program number. The example below shows that the installed processor program is 42C 000100P and the installed communication program (link) is 42C000100L.

Send: "program no"
Receive: "program no processor 42C 000100P clink 42 C000100L"

bright

This command reports the screen's level of brightness. The example below shows the screen brightness is 75%.

Send: "bright"
Receive: "bright 75%"

set bright *d*

This command reports the screen's level of brightness. The example below sets the brightness level to 50%.

Send: "set bright 1"
Receive: "set bright 1 ok"

d	Brightness level
0	25%
1	50%
2	75%
3	100%

bat

This command reports the current voltage of the battery on the clink card. The example below shows that the voltage is 3.1 volts.

Send: "bat"
Receive: "bat 3.1 volts"

set save params

This command stores parameters in the EEPROM. It is important that each time instrument parameters are changed, that this command be sent. If changes are not saved, they will be lost in the event of a power failure. The example below saves the parameters to EEPROM.

Send: "set save params"
Receive: "set save params ok"

save

Send: "save"
Receive: "save ok"

set default params

This command sets all the parameters to the default values.

Send: "set default params"
Receive: "set default params ok"

These values are not saved in the EEPROM until the user issues a "set save params" command.

screen

This reports the information currently being displayed on the instrument's front panel display. The example below shows a typical response to this command.

Send: "screen"
Receive: "screen
                NO   PPM   40.0
                NO2   PPM   29.5
                NOx   PPM   69.5
                SAMPLE 14:25   REMOTE"

push *button*

button = | run | menu | enter | help | up | down | left | right |

This command is used to simulate pressing the Model 42C High Level front panel pushbuttons. In the example below, the push command is used in conjunction with the screen command to view the Main Menu. Note that the instrument was in the Run screen initially.

Send: "screen"
Receive: "screen
               MAIN MENU: 10:25
               >RANGE
                 AVERAGING TIME
                 CALIBRATION FACTORS"

flags

This reports 8 hexadecimal digits (or flags) that represent the status of the ozonator, PMT, gas mode, and alarms. To decode the flags, each hexadecimal digit is converted to binary as shown in the figure below. It is the binary digits that define the status of each parameter. In the example below, the instrument is reporting that the ozonator and PMT are both on, that the instrument is in the span gas mode, that at least one of the alarm temperature is activated, and that the NO_2 high concentration alarm is activated.

Send: "flags"
Receive: "flags C0028008"

Flags (hex digits)

Convert to binary (see conversion table)

C0028008

Alarms

NO concentration alarm
NO2 concentration alarm
NOx concentration alarm
Reserved TEI
Pressure
Sample Flow
Ozonator Flow
Temperature alarm (any)

Alarm Status

00 = no alarm
01 = low alarm
10 = high alarm

Not Used

Gas Mode Status:
00 = sample
01 = zero
10 = span

Gas Unit:
00 = ppb
01 = ppm
10 = $\mu g/m^3$
11 = mg/m^3

Not Used

Meas. Mode
00 = auto
01 = manual NO
10 = manual NO_x

Pressure Comp.*
Temperature Comp.*

Mode:
00 = local
01 = remote
10 = service
11 = service

PMT on/off*
Ozonator on/off*

NOTE:
* 0 = off, 1 = on

Hex to Binary Conversion Table

0 = 0000		8 = 1000	
1 = 0001		9 = 1001	
2 = 0010		A = 1010	
3 = 0011		B = 1011	
4 = 0100		C = 1100	
5 = 0101		D = 1101	
6 = 0110		E = 1110	
7 = 0111		F = 1111	

FLAG STATUS— 42C STANDARD
LOGO TRANSLATOR

DRAWING NUMBER   REV.
64P280   B

format

This command reports the current reply termination format as shown below. The example below shows that the reply format is 00, which means reply with no checksum.

Send: "format"
Receive: "format 00"

Code	Reply Termination
00	<CR>
01	<nl> sum xxxx <CR>

Where xxxx is the sum of all characters in the reply message

set format *dd*

dd = | 00 | 01 |

This command sets the reply termination format. The example below sets the reply termination format to checksum.

Send: "set format 01"
Receive: "set format 01 ok"

Code	Reply Termination
00	<CR>
01	<nl>sum xxxx<CR>

where xxxx = 4 hexadecimal digits that represent the sum of all the characters in the message

lrec mem size

This command reports the maximum number of long records that can be stored with the current settings and the number of blocks reserved for long records. To calculate the number of long records per block, add 2 to the number of records, and then divide by the number of blocks. The example below shows that 7 blocks were reserved for long records, and the maximum number of long records that can be stored in memory is 1426 records.

Send: "lrec mem size"
Receive: "lrec mem size 1426 recs, 7 blocks"

set lrec blocks *dd*

This command sets the number of blocks to be used to save 1recs. 15-*dd* is the number of blocks to be used to save srecs. To calculate the number of blocks needed for a certain number of records, use the number of records per block as given above.

Send: "set lrec blocks 7"
Receive: "set lrec blocks 7 ok"

srec mem size

This command reports the maximum number of short records that can be stored with the current settings and the number of blocks reserved for short records. To calculate the number of short records per block, add 2 to the number of records, and then divide by the number of blocks. The example below shows that 8 blocks were reserved for short records, and the maximum number of short records that can be stored in memory is 2726 records.

Send: "srec mem size"
Receive: "srec mem size 2726 recs, 8 blocks"

no of lrec

This reports the number of long records stored in the long records memory. The example below shows that 50 long records have been stored in the memory.

Send: "no of 1rec"
Receive: "no of 1rec 50 recs"

no of srec

This reports the number of short records stored in the short records memory. The example below shows that 250 short records have been stored in the memory.

Send: "no of srec"
Receive: "no of srec 250 recs"

set clr records

This command will clear any records that have been saved.

Send: "set clr records"
Receive: "set clr records ok"

lrec per

This command reports the lrec logging period. The example below shows that the long record logging period is 5 minutes.

Send: "1rec per"
Receive: "1rec per 5 min"

set lrec per *dd*

dd = │ 1 │ 5 │ 15 │ 30 │ 60 │

This command sets the lrec logging period to every *dd* minutes.

Send: "set lrec per 15"
Receive: "set lrec per 15 ok"

srec per

This command reports the srec logging period. The example below shows that the short record logging period is 1 minute.

Send: "srec per"
Receive: "srec per 1 min"

set srec per *dd*

dd = │ 1 │ 5 │ 15 │ 30 │ 60 │

This command sets the srec logging period to every dd minutes.

Send: "set srec per 15"
Receive: "set srec per 15 ok"

record formats

Long and short records, and dynamic data can be output in various formats such as ASCII without text, ASCII with text, or binary. The following commands report and set the current output format for long (lrec) and short records (srec), and dynamic data (erec).

Records can be output in the following ways:

Format	Output Format
0	ASCII no text
1	ASCII with text
2	binary data

lrec format
srec format
erec format

These commands report the output format for long and short records, and dynamic data. The following example shows that the output format for long records is ASCII with text.

Send: "lrec format"
Receive: "lrec format 01"

---

set lrec format *f*
set srec format *x*
set erec format *y*

$f =$ │ 0 │ 1 │ 2
$x =$ │ 0 │ 1 │ 2   For settings, refer to the output format shown above.
$y =$ │ 0 │ 1 │ 2

These commands set the output format. The following example sets the lrec output format to ASCII with text.

Send: "set lrec format 1"
Receive: "set lrec format 1 ok"

---

lrec
srec
lrec *xxxx yy*
srec *xxxx yy*
lrec *aa:bb oo-pp-qq yy*
srec *aa:bb oo-pp-qq yy*

xxxx = the number of past records
yy = the number of records to return (1 to 10)
aa = hours (01 to 24, military time)
bb = minutes (00 to 59)
oo = month (01 to 12)
pp = day (01 to 31)
qq = year (enter "00" for the year 2000)

These commands output long or short records. The output format is determined by the *set lrec format* and *set srec format* commands. The logging time is determined by the *set lrec per* and *set srec per* commands. In dual range, the long records and short records contain the high and low NO and NOx concentrations. In single range the low NO and low NOx values are set to 0 and the high NO and high NOx are used. In NO or NOx only mode, the pertinent high value used, other concentrations are set to 0. Concentrations are stored in either ppm or $\mu g/m^3$.

In the following example, there are 740 long records currently stored in memory. When the command *lrec 100 5* is sent, the instrument counts back 100 records from the last record collected (record 740), and then returns 5 records: 640, 641, 642, 643, and 644.

Send: "lrec 100 5"
Receive: "lrec 100 5

11:03 02-22-03 flags 54089100 no 8416E-1 nox 8458E-1 lono 6474E-1 lonox
6506E-1 pres 131.4 pmtt 53.1 intt 80.0 rctt 80.0 convt 61 smplf 0.500 ozonf 0.000 pmtv -116
11:04 02-22-03 flags 54089100 no 8421E-1 nox 8457E-1 lono 6477E-1 lonox
6505E-1 pres 131.5 pmtt 53.1 intt 80.0 rctt 80.0 convt 61 smplf 0.500 ozonf 0.000 pmtv –116
11:05 02-22-03 flags 54089100 no 8440E-1 nox 8456E-1 lono 6492E-1 lonox
6505E-1 pres 131.5 pmtt 53.2 intt 80.0 rctt 80.0 convt 61 smplf 0.500 ozonf 0.000 pmtv –116
11:06 02-22-03 flags 54089100 no 8432E-1 nox 8483E-1 lono 6486E-1 lonox
6525E-1 pres 133.0 pmtt 53.0 intt 80.0 rctt 80.0 convt 61 smplf 0.500 ozonf 0.000 pmtv –116
11:07 02-22-03 flags 54089100 no 8442E-1 nox 8383E-1 lono 6494E-1 lonox
6449E-1 pres 131.5 pmtt 53.1 intt 80.0 rctt 80.0 convt 61 smplf 0.500 ozonf 0.000 pmtv –116
sum cd3e"

where:

pmtv = PMT Voltage
pmtt = PMT Temperature
intt = Internal Temperature
rctt = Reaction Chamber Temperature
convt = NO_2 Converter Temperature
smplf = Sample Flow
ozonf = Ozonator Flow
pres = Pressure

erec

This command returns a brief description of the main operating conditions at the time the command is issued (i.e. dynamic data). The example below shows a typical response.

Send: "erec"
Receive: "erec
             09:54 03-26-03   flags 58009200 no 32.6 nox 33.2 no2 0.5 1 lono 16.4
             lonox 16.5 lono2 0.2 1 pmtv -113 tempal 4 pres 128.6 pcal 85.5 smplf
             0.500 ozonf 0.000 hiavgtime 300 loavgtime 10 nobkg 48 noxbkg 47
             nocoef 1.000 noxcoef 1.000 no2coef 1.000 lonocoef 0.500 lonoxcoef
             1.000 lono2coef 1.000 norange 200.0 noxrange 200.0 no2range 200.0
             lonorange 200.0 lonoxrange 200.0 lono2range 200.0"

er*xy*

$x = | 0 | 1 |$: Reply termination format (see "set format *dd*" command)
$y = | 0 | 1| 2|$: Output format (see "*set lrec format f*" command)

This command returns a brief description of the main operating conditions at the time the command is issued (i.e. dynamic data) with no checksum, in ASCII format with text.

Send: "er01"
Receive: "er01
             12:31 02-22-03 flags 54089100 no 843. nox 852. no2 9.0 lono 649. lonox
             656. lono2 7. 0 pmtv –116 tempal 4 pres 131.3 pcal 116.0 smplf 0.500
             ozonf 0.001 hiavgtime 10 loavgtime 10 nobkg 0.0 noxbkg 0.0 nocoef
             1.300 noxcoef 1.000 no2coef 1.000 lonocoef 1.000 lonoxcoef 1.000
             lono2coef 1.000 norange 150000 noxrange 150000 no2range 150000
             lonorange 500 lonoxrange 500 lono2range 500"

sr*xy*

x = | 0 | 1 | : Reply termination format (see "set format *dd*" command)
y = | 0 | 1| 2| : Output format (see "*set srec format x*" command)

This command reports the last short record stored. In the example below, the command requests a short record with no checksum, in ASCII format with text.

Send: "sr01"
Receive: "sr01
                   12:31 02-22-03 flags 54089100 no −8413E-1 nox −8485E-1 lono −6471E-
                   1 lonox −6527E-1"

lr*xy*

x = | 0 | 1 | : Reply termination format (see "set format *dd*" command)
y = | 0 | 1| 2| : Output format (see "*set erec format y*" command)

This command reports the last long record stored. In the example below, the command requests the data with no checksum, in ASCII format with text.

Send: "lr01"
Receive: "lr01
                   12:31 02-22-03 flags 54089100 no −8413E-1 nox −8485E-1 lono −6471E-
                   1 lonox −6527E-1 pres 130.9 pmtt 53.2 intt 80.0 rctt 80.0 convt 61 smplf
                   0.500 ozonf 0.000 pmtv −115"

baud

This reports the current baud rate of the connection. The example below reports that the current baud rate is 9600.

Send: "baud"
Receive: "baud 9600"

set baud *rate*

rate = | 1200 | 2400 | 4800 | 9600 |

This command sets the instrument baud rate. After the command is sent, the baud rate of the sending device must be changed to agree with the instrument. The example below sets the instrument's baud rate to 9600. Thermo Environmental Instruments recommends that you use a baud rate of 9600 when operating this instrument.

Send: "set baud 9600"
Receive: "set baud 9600 ok"

APPENDIX C
INTERNAL PERMEATION SPAN SOURCE (Optional)

The Internal Permeation Span Source option is designed to provide a simple zero and span check. Because this option does not precisely control dilution gas flow, it should not be used as a basis for analyzer zero and span adjustments, calibration updates or adjustment of ambient data. This option is intended as a quick, convenient check to be used between zero and span calibrations for determining analyzer malfunction or drift. Whenever there is an indication of possible analyzer drift or malfunction, a full zero and multipoint calibration (Level 1) should be performed prior to corrective action. For further information on zero, span and calibration of air pollution monitors, refer to Section 2.0.9 of the US EPA's Quality Assurance Handbook for Air Pollution Measurement Systems (Volume II).

The method of operation of the Model 42C with this option can be seen by referring to Figure C-1. Energizing valve V1 shuts off the sample flow and permits the flow of zero air for analysis. When valves V1 and V2 are energized, the flow of zero air is blended with air containing NO_2 from the permeation oven. This mode of operation provides a single point span check.
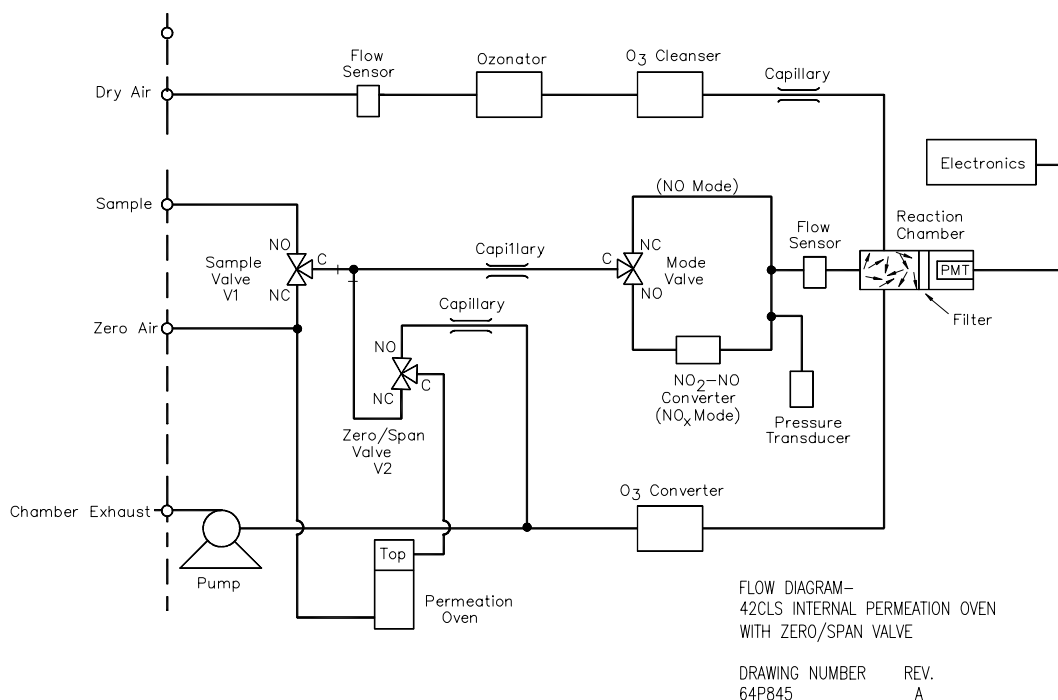
Figure C-1. Flow Diagram, Internal Permeation Oven with Zero/Span Valve

SPECIFICATIONS

Temperature control	Single Point 45°C
Temperature stability	±0.1° C
Warm-up time	1 hour (permeation device can take 24 to 48 hours to stabilize)
Carrier gas flow	≈ 70 scc/min
Chamber size	Accepts permeation tubes up to 9 cm in total length; 1 cm in diameter.
Temperature range	10 to 30° C
Physical dimensions	Contained inside the Model 42C.
Power requirements	50 watts, 50/60 Hz, 120/220 VAC (in addition to the standard Model 42C).
Weight	Approximately 5 lbs. (in addition to the standard Model 42C).
Remote operation	RS-232 Interface or Contact Closure

PERMEATION TUBE INSTALLATION

1. Remove the oven cover.
2. Remove the glass chamber assembly by loosening (not removing) the knurled screw and gently pulling the assembly upward. Completely remove from the oven.
3. Separate the glass chamber from the top assembly by twisting and gently pulling the glass away from the top.
4. Keep the glass clean when handling the glass.
5. Place permeation tube(s) in chamber.
6. Attach the glass chamber to the top assembly by gently pushing the two together with a slight twisting motion.
7. Replace the glass chamber assembly into the oven until top of the assembly is flush or slightly below the top of the oven.
8. Tighten the knurled screw finger-tight.
9. Do not use tools to tighten.
10. Replace the oven cover, being sure to place the tubing and wire into the slot of cover.

COMPUTATION OF CONCENTRATIONS

The computation of the NO_2 output level is shown below. Note that it is assumed that all devices are properly calibrated and that all flows are corrected to 25° C and 1 atm.

Permeation Tube:

$$Output\ (ppm) = \frac{(R)\ (K)}{Q_o}$$

Where:

R = permeation rate in ng/min

Q_o = dilution flow rate of gas (scc/min) during span mode.

K = constant for the specific permeating gas = 24.45/MW

MW = molecular weight

K (NO_2) = 0.532

OVEN TEMPERATURE CORRECTION CALIBRATION (D/A 4)

The Model 42C uses the oven temperature correction signal (D/A 4) to maintain a constant temperature in the permeation oven. Follow the procedure below to calibrate D/A 4:

1. From the Service Mode menu select Permeation Oven.
2. From the Permeation Oven menu select Cal DTOA #4. Press **ENTER** to set D/A #4 to 0 volts. The screen below appears.

```
DTOA #4               0
SET TO            1000?
adj  z4  for  0.000 V
between pins  7 and 8
```

Cal DTOA #4 Screen

3. Adjust Z4 on the Digital/Analog Board until 0.000 volts is measured across pins 7 and 8 on the rear panel analog output connector.
4. Press **ENTER** to set D/A 4 to 10 volts. Adjust SP4 on the Digital/Analog Board until 10.000 volts is measured across pins 7 and 8.
5. Press **MENU** to return to the Permeation Oven menu.

PERMEATION TUBE OVEN CALIBRATION

There are two general methods that can be used to calibrate the permeation tube oven. The first calibrates the temperature indicator very accurately (to better than 0.02° C), and uses a permeation tube whose weight loss has been previously determined at that temperature (note, an error of about 0.1° C corresponds to an error of approximately 1% in release rate). The second approach notes that the thermistors used to measure temperature are interchangeable to better that ± 0.2°C. Thus a 1% resistor of the proper value (4.369 K ohm for 45° C) can be used to set the span on the Oven Controller Board. The release rate for the permeation tube is then determined by weight loss in the actual oven being used.

Calibration Method 1 - Setting Measure Temperature With Water Bath

1. Unplug J3 from the Oven Controller Board. Place a 4.369 KΩ resistor across pins 3 and 4 of J3 on the Oven Controller Board.
2. From the Permeation Oven menu, select Cal Oven Thermistor. Adjust R2 on the Oven Controller Board until the oven drive voltage is 5.000 volts. Press **MENU** to return to the Permeation Oven menu.

```
OVEN DRIVE   4.848 V
replace gas therm
with 4369 ohms,
adj R2 for 5.000 V
```

Cal Oven Thermistor Screen

3. Remove the thermistor from the permeation tube oven. Leave the thermistor connected to the Oven Controller Board. Insert the thermistor into the water bath next to a NIST traceable thermometer. (If necessary, use an extension cable to reach).
4. Turn on the power to the water bath. Using an NIST traceable thermometer with a resolution of ± 0.01° C, adjust water bath to 45.00° C.
5. From the Permeation Oven menu, select Cal Gas Thermistor. Adjust R4 on the Oven Controller Board until the permeation gas temperature reading is 45.00° C.

```
PERM GAS     45.00 °C
replace gas therm
with 4369 ohms,
adj R4 for 45.00 °C
```

Cal Gas Thermistor Screen

6. Remove thermistor from the water bath, dry, and replace into the permeation tube oven.
7. Make sure that zero air is connected to the **ZERO** bulkhead on the rear panel.
8. Wait for the permeation gas temperature reading to stabilize.
9. From the Permeation Oven menu, select Set Gas Temperature. Adjust R2 until the Perm Gas reading displayed on the first line is 45.00° C. Since it takes several minutes for the permeation oven temperature to stabilize, wait several minutes between adjustments.

```
PERM GAS     45.00 °C
OVEN DRIVE   4.848 V
adj R2, wait 10 min,
repeat until 45.0 °C
```

Set Gas Temperature Screen

Calibration Method 2 - Setting Measure Temperature with an Accurately Known Oven Temperature

1. Unplug J3 from the Oven Controller Board. Place a 4.369 KΩ resistor across pins 3 and 4 of J3 on the Oven Controller Board.
2. From the Permeation Oven menu, select Cal Oven Thermistor. Adjust R2 on the Oven Controller Board until the oven drive voltage is 5.000 volts. Press **MENU** to return to the Permeation Oven menu.

```
OVEN DRIVE   4.848 V
replace gas therm
with 4369 ohms,
adj R2 for 5.000 V
```

Cal Oven Thermistor Screen

3. Remove thermistor from J1 on the Oven Controller Board.
4. Connect a resistance of 4.369 KΩ across pins 1 and 2 of J1 (use a resistance substitution box and an accurate meter if necessary).
5. From the Permeation Oven menu, select Cal Gas Thermistor. Adjust R4 on the Oven Controller Board until the permeation gas temperature reading is 45.00° C.

```
PERM GAS      45.00 °C
replace gas therm
with 4369 ohms,
adj R4 for 45.00 °C
```

Cal Gas Thermistor Screen

6. Reconnect measure thermistor.
7. Make sure the source of zero air is connected to the **ZERO** bulkhead on the rear panel.
8. Wait for the permeation gas temperature reading to stabilize.
9. From the Permeation Oven menu, select Set Gas Temperature. Adjust R2 until the Perm Gas reading displayed on the first line is 45.00° C. Since it takes several minutes for the permeation oven temperature to stabilize, it is best to wait 10 minutes between adjustments.

```
PERM GAS      45.00 °C
OVEN DRIVE    4.848 V
adj R2, wait 10 min,
repeat until 45.0 °C
```

Set Gas Temperature Screen

DETERMINATION OF PERMEATION RATE BY WEIGHT LOSS

1. Make sure the oven has been calibrated as described above.
2. Insert the permeation tube carefully. Do not touch with fingers.
3. Turn on the Model 42C.
4. Wait 24 to 48 hours for the permeation tube to stabilize.
5. Carefully remove the permeation tube from the oven and weigh to an accuracy of 0.1 mg. Perform this measurement as quickly as possible.
6. Replace permeation tube into the oven of the Model 42C.
7. Repeat steps 5 and 6 after two weeks.
8. Compute the weight loss of the permeation tube from the values determined in steps 5, 6, and 7 above.
9. Repeat steps 5 to 8 until the weight loss has been determined to a precision of 1 to 2%.
10. For most accurate work, use the permeation tube in the same oven that was used to determine the permeation tube's weight loss.

DETERMINATION OF RELEASE RATE BY USE OF TRANSFER STANDARD

1. Make sure the permeation oven temperature in the Model 42C has been calibrated. Also make sure that the Transfer Standard has been properly calibrated.
2. Determine the permeation rate for the permeation tube in the Transfer Standard, or install a certified permeation tube.
3. Allow the permeation tubes in both instruments, Model 42C and Transfer Standard, to stabilize 24 to 48 hours.
4. Carefully calibrate the Model 42C using the Transfer Standard. The output of the Transfer Standard should be connected to the sample bulkhead on the rear panel of the Model 42C.
5. Switch the calibrated Model 42C into the span mode. Measure the flow rate into the **ZERO** bulkhead on the rear panel of the Model 42C. Be sure that the source of zero air is connected. Note the flow and the measured NO_2 concentration.
6. From the flow and measured concentration, compute the permeation tube release rate.
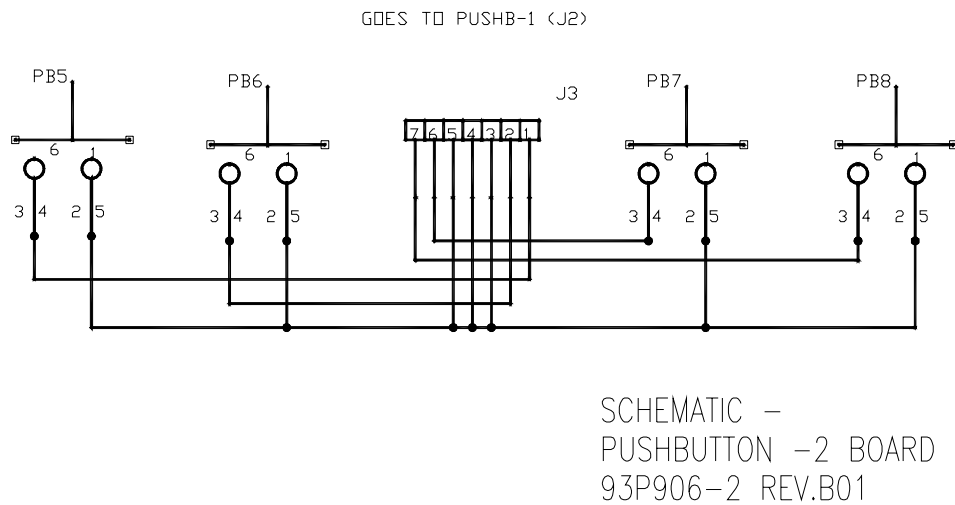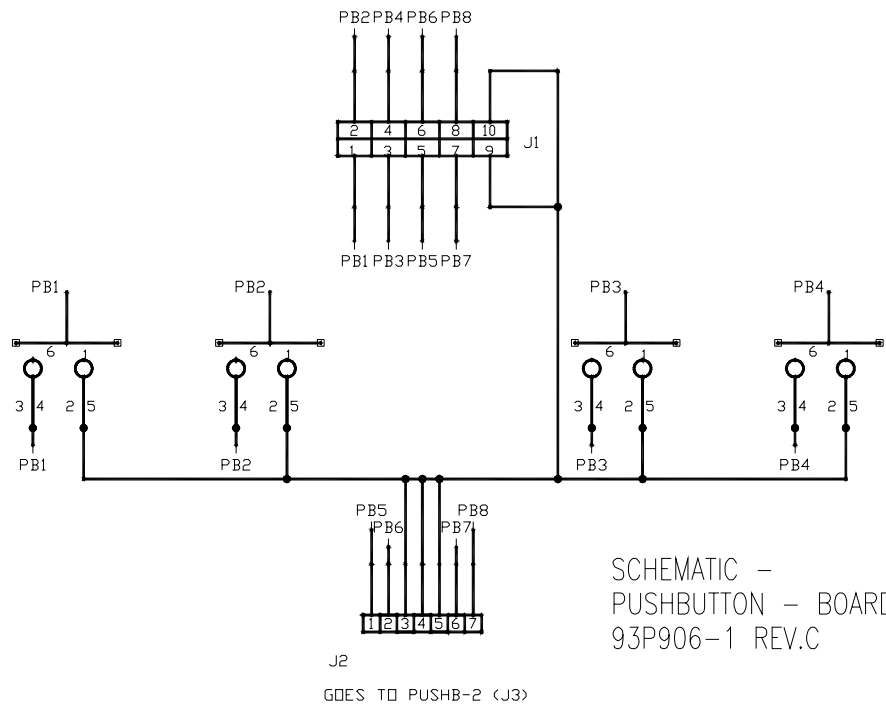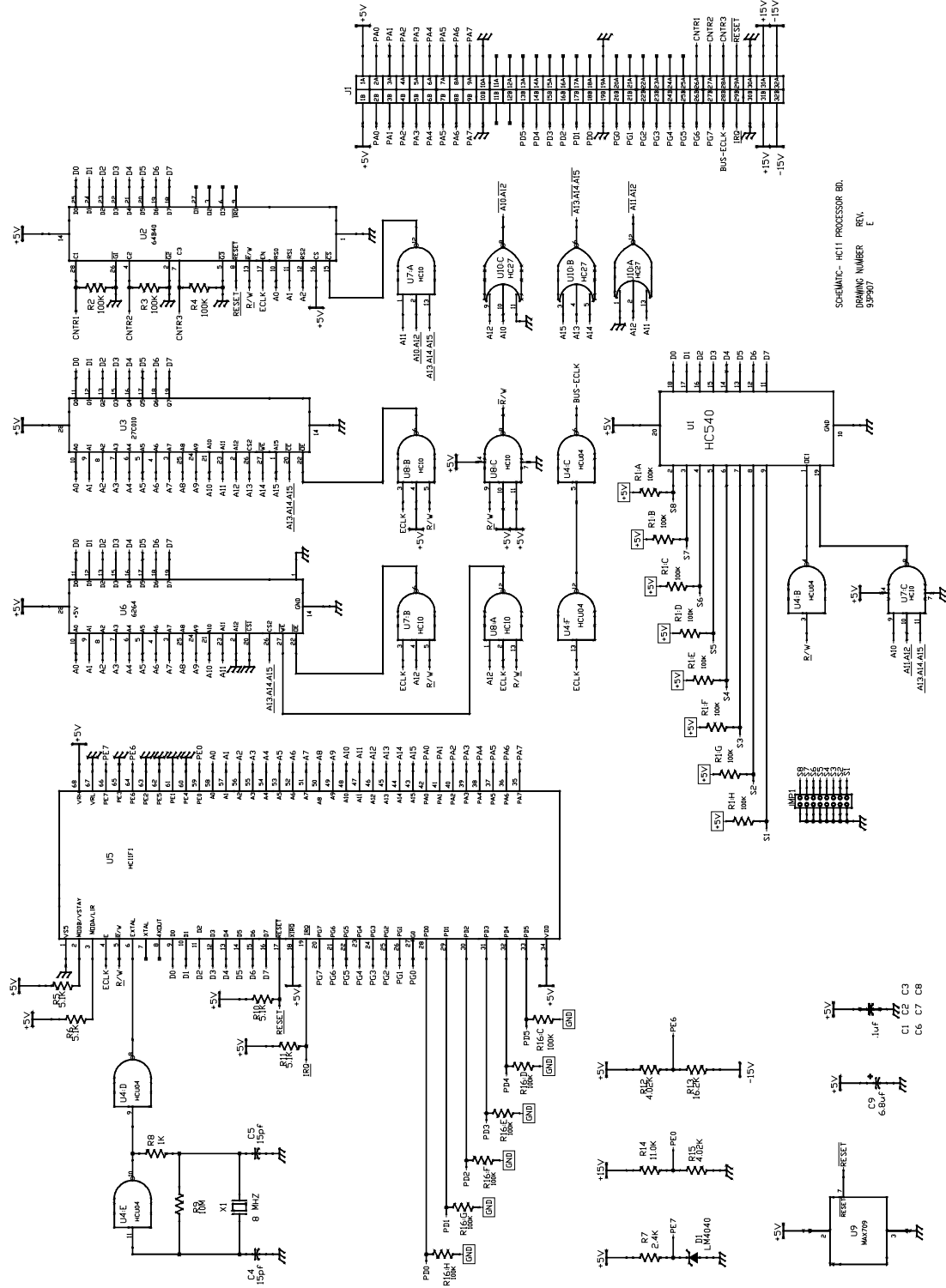
APPENDIX D
SCHEMATICS

This appendix contains the schematics for the standard and optional printed circuit boards contained in the Model 42C. Always turn off the instrument and unplug the power cord before removing any printed circuit board. For more information about appropriate safety precautions, see Chapter 7, Servicing. A description of each board can be found in Chapter 8, Theory of Operation.

PC Board	Schematic No.	Part No.	Page
Motherboard	64P943	9827	D-2
Pushbutton Board 1	93P906	9950	D-3
Pushbutton Board 2	93P906	9952	D-3
Processor Board	93P907	9837	D-4
Analog/Digital Board	64P946	9841	D-5
Digital/Analog Board	93P908	9839	D-6
Power Supply Board	64P942	9845	D-7
Ozonator Board	64P944	9946	D-8
Input Board	64P941	9948	D-9
Temperature Control Board (Stainless Steel Converter)	64P945	10765	C-10
Temperature Control Board (MolybdenumConverter)	64P945	9940 (Optional)	C-10
C-Link Board	93P914	9843	D-11
4-20 mA Outputs (Optional)	93P912	9954	D-12
Perm Oven Controller Optional)	57P960	8953	D-13
Input/Output Board (Optional)	93P913	9956	D-14
Rear Connector Interface Board	93P915	9904	D-15

PB2 PB4 PB6 PB8

| 2 | 4 | 6 | 8 | 10 | J1
|---|---|---|---|---|
| 1 | 3 | 5 | 7 | 9 |

PB1 PB3 PB5 PB7

PB1   PB2   PB3   PB4

6   1   6   1   6   1   6   1

3 4 2 5   3 4 2 5   3 4 2 5   3 4 2 5

PB1   PB2   PB3   PB4

PB5   PB8
PB6   PB7

1	2	3	4	5	6	7

J2

GOES TO PUSHB-2 (J3)

SCHEMATIC –
PUSHBUTTON – BOARD
93P906-1 REV.C

GOES TO PUSHB-1 (J2)

PB5   PB6   J3   PB7   PB8

6   1   6   1 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 6   1   6   1

3 4 2 5   3 4 2 5   3 4 2 5   3 4 2 5

SCHEMATIC –
PUSHBUTTON –2 BOARD
93P906-2 REV.B01

D-3

SCHEMATIC- HC11 PROCESSOR BD.
REV. E
DRAWING NUMBER
93P907
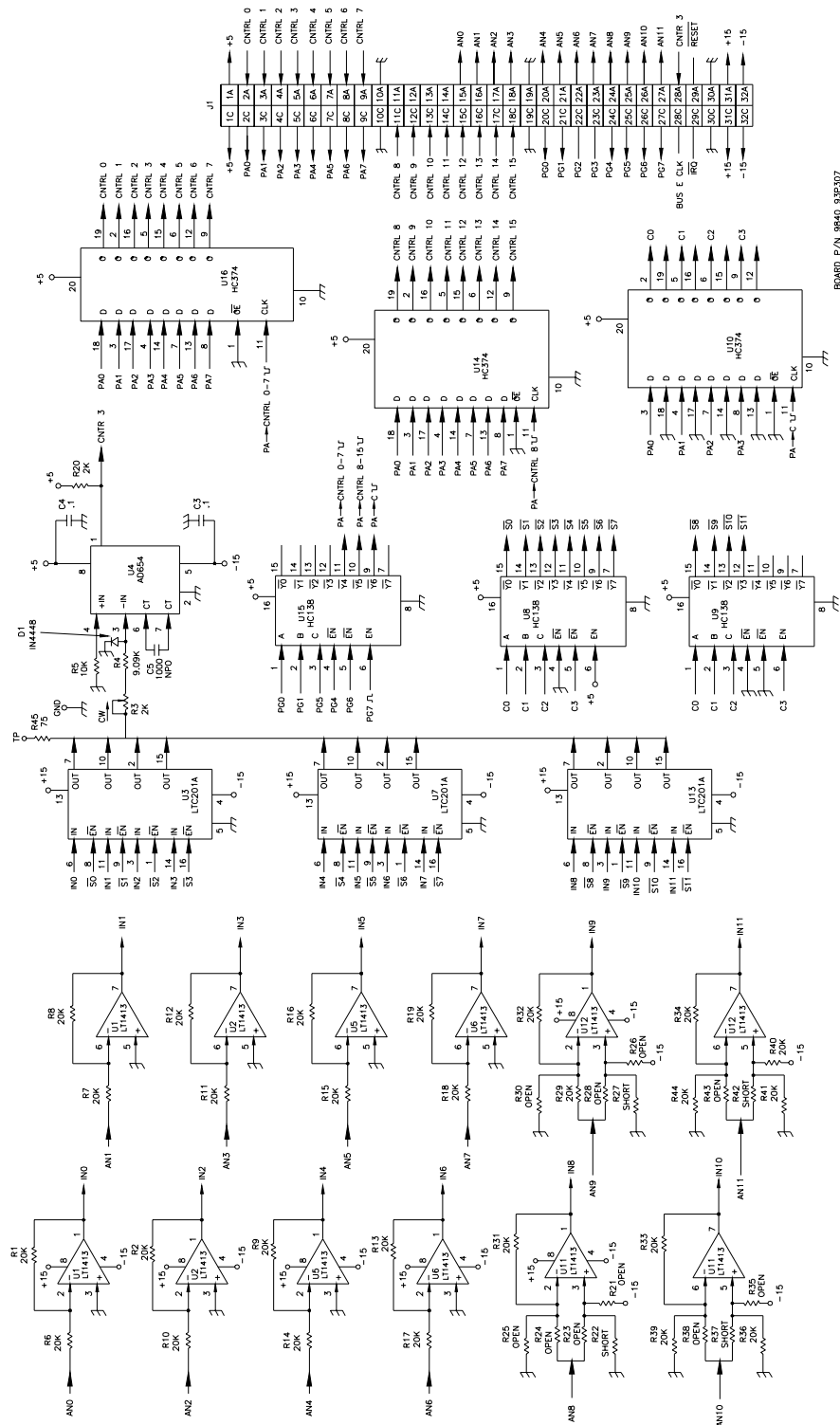
SCHEMATIC – ANALOG/DIGITAL BOARD

64P946 REV.F

BOARD P/N 9840 93P307
ASSY. P/N 9841 64P7191

SCHEMATIC- DIGITAL/ANALOG BD. REV. A

DRAWING NUMBER
93P908

D-6
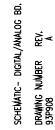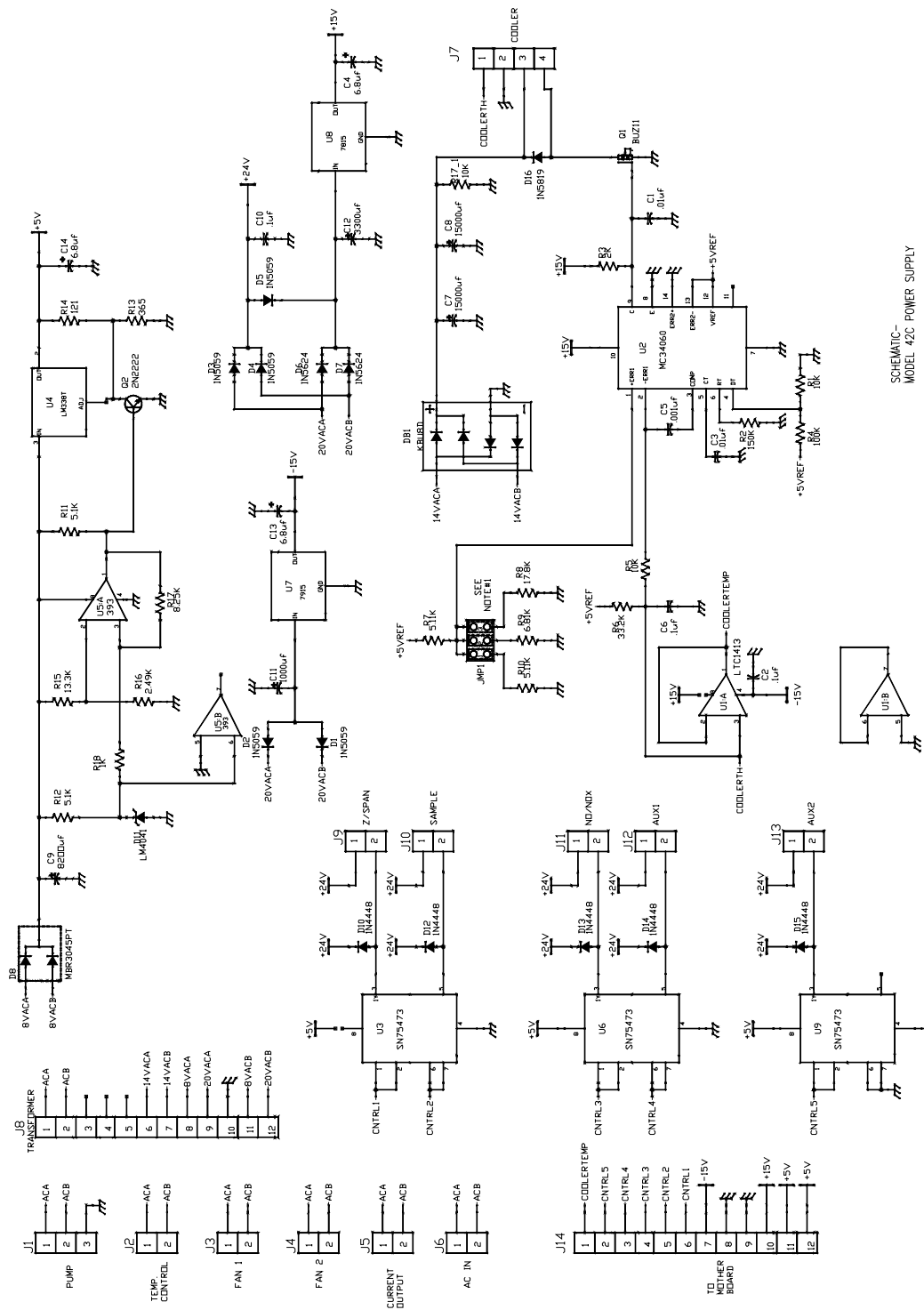
SCHEMATIC-
MODEL 42C POWER SUPPLY

DRAWING NUMBER   REV
64P942   M

SCHEMATIC- 42C OZONATOR DRIVER BD.

DRAWING NUMBER 64P944   REV. E01

JUMPER POSITION	ASY P/N
1 AND 2	9946
2 AND 3	10767

NOTE#1

MODEL 42C, 42CNⅡx, 17C

MODEL 42CHL, 42CTL, 42CLS, 42CNI
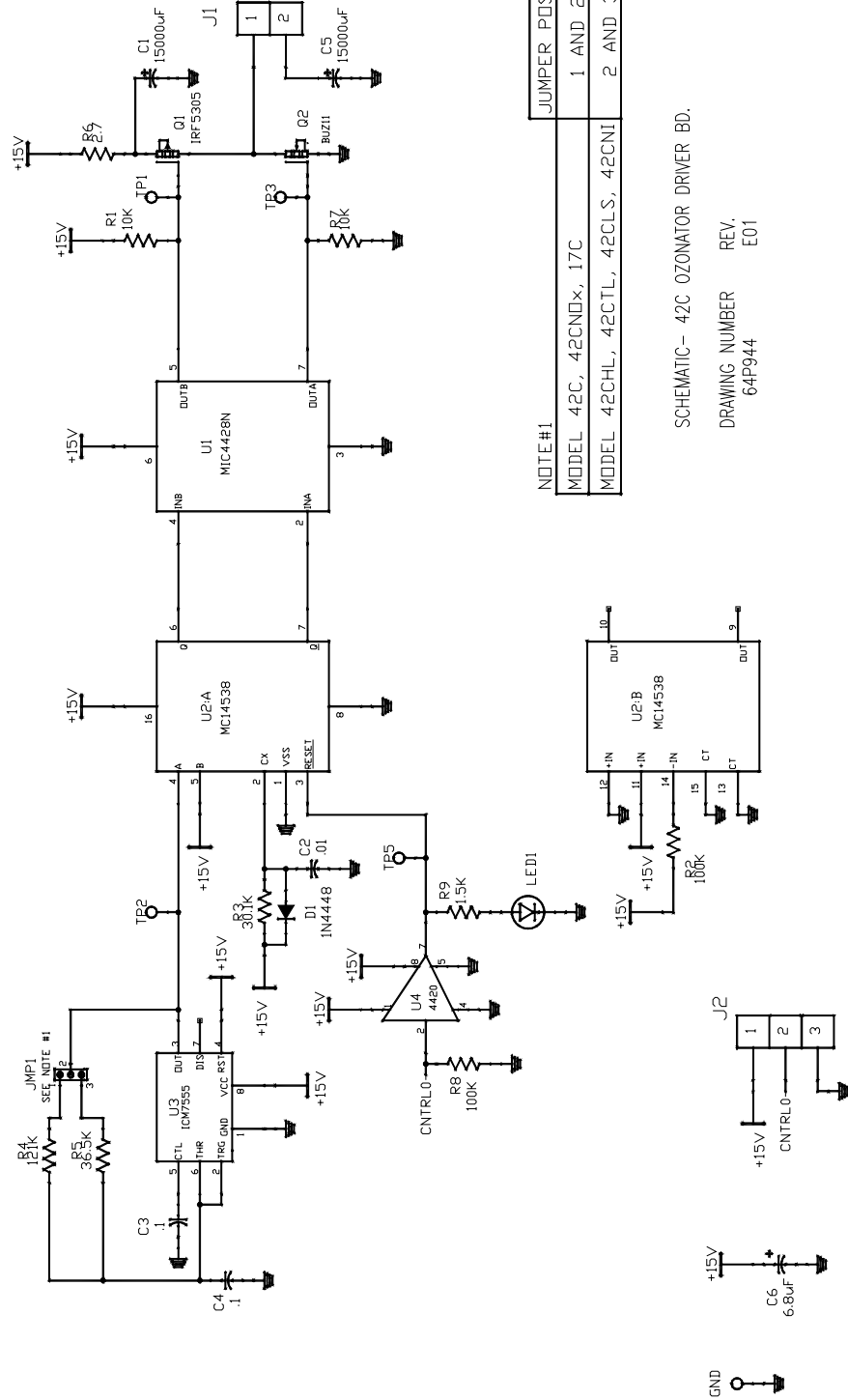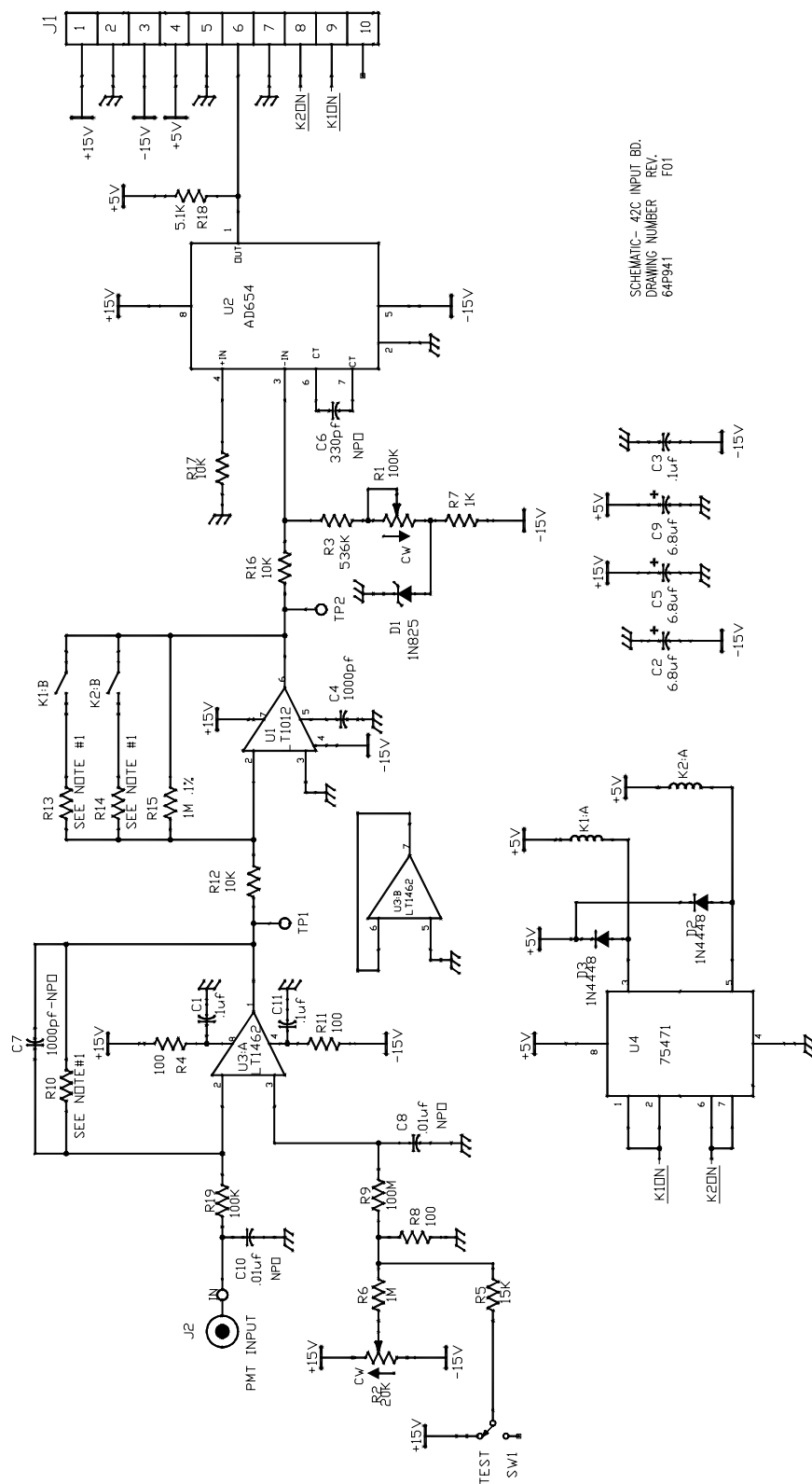
SCHEMATIC- 42C INPUT BD.
DRAWING NUMBER   REV.
64P941   F01

NOTE #1		R10 VALUE	R13 VALUE	R14 VALUE	ASSY. P/N
MOD. 42C		100M	10K -1%	110K -1%	9948
MOD. 42CHL		1M	10K -1%	110K -1%	10766
MOD. 42CTL		100M	52.3K -1%	246K -1%	14025

D-9

SCHEMATIC- 42C TEMPERATURE CONTROL BD.
DRAWING NUMBER   REV.   E
64P945

D-10

SCHEMATIC- CURRENT OUTPUT (4 CHANNEL)
REV. B01
DRAWING NUMBER
93P912
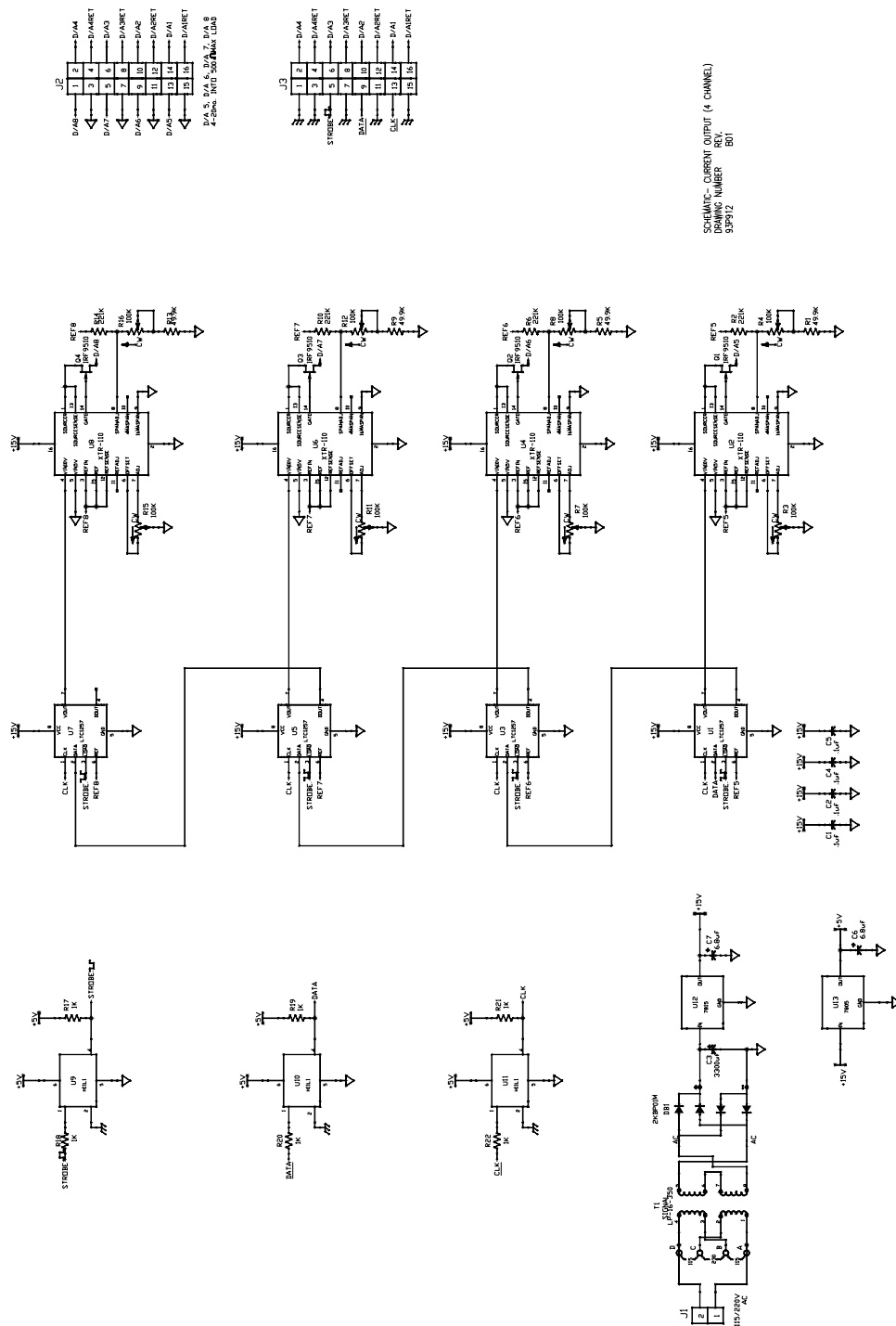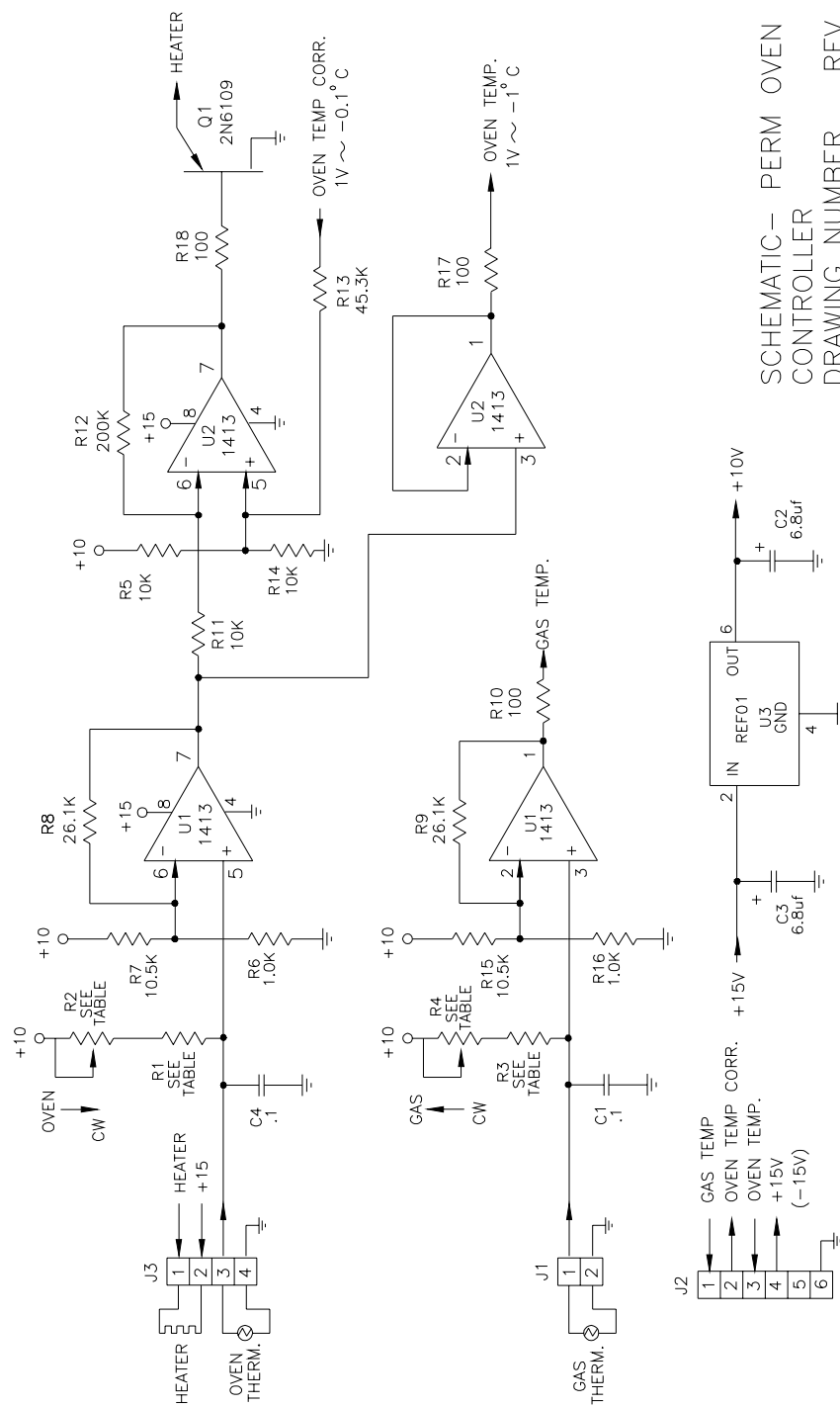
SCHEMATIC- PERM OVEN
CONTROLLER
DRAWING NUMBER   REV. E
57P960

HEATER

Q1
2N6109

OVEN TEMP CORR.
1V ~ -0.1°C

R18
100

R13
45.3K

OVEN TEMP.
1V ~ -1°C

R17
100

R12
200K

7
+15 8
U2
1413
4
6 −
5 +

U2
1413
1
2 −
3 +

+10
R5
10K

R14
10K

R11
10K

GAS TEMP.

R10
100

R8
26.1K

7
+15 8
U1
1413
4
6 −
5 +

R9
26.1K

1
U1
1413
2 −
3 +

+10
R7
10.5K

R6
1.0K

+10
R15
10.5K

R16
1.0K

R2
SEE
TABLE

+10
OVEN
CW

R1
SEE
TABLE

C4
.1

R4
SEE
TABLE

+10
GAS
CW

R3
SEE
TABLE

C1
.1

+10V

C2
6.8uf

2 IN REF01 OUT 6
U3
GND
4

C3
6.8uf

+15V

J3
1 HEATER
2 +15
3
4

HEATER
OVEN
THERM.

J1
1
2

GAS
THERM.

J2
1 GAS TEMP
2 OVEN TEMP CORR.
3 OVEN TEMP.
4 +15V
5 (−15V)
6

RESISTOR TABLE:
FOR 30.0°C TEMP.   R1 AND R3 = 69.8k(1/4W 1% P/N 49985)
FOR 35.0°C TEMP.   R1 AND R3 = 56.2K
FOR 45.0°C TEMP.   R1 AND R3 = 38.3K
FRO 30.0°C TEMP; REPLACE R2 & R4 ONLY, WITH A 5K POT(M146C ONLY)

SCHEMATIC —
INPUT/OUTPUT
BOARD
93P913 REV. C

BOARD RAW P/N 9955 93P318
BOARD ASY P/N 9956 93P719

NOTE: SYSTEM GROUND
SIGNAL GROUND

D-14

SCHEMATIC- REAR CONNECTOR INTERFACE
DRAWING NUMBER   REV.
93P915   E01

D-15

APPENDIX E
VACUUM PUMP DIAPHRAGM AND VALVE REPLACEMENT PROCEDURE

This appendix describes the diaphragm and valve replacement for the TEI vacuum pumps, part numbers: 9456 (115v/60Hz) and 9457 (220v/50Hz).

EQUIPMENT NEEDED

Use the following equipment to complete the replacement of the diaphragm and valve:

- 4 mm allen-head wrench
- 7/32" nut driver or 5.5 mm nut driver
- 3 mm allen-head wrench
- Spanner wrench: 3.8 mm diameter, by 4.5 mm long inserts
- Small flat blade screw driver
- Large flat blade screw driver
- Cleaning agent (alcohol)
- Fine-grade steel wool
- "LOC-TITE" blue breakable thread adhesive

DIAPHRAGM REPLACEMENT PROCEDURE

Use the following procedure and Figure E-1 to replace the diaphragm.

1. Undo the four socket head cap screws and washers ("C") for each head and lift off the heads with tubing from the pump body. Keep the heads connected if at all possible: disconnecting and then reconnecting the PTFE tube can cause leaks.

2. Check for smooth opening and closing of the reed valves ("Q"): a number of sets of diaphragms can be replaced before there is a need to replace the valves. Follow the instructions for "valve replacement" if changing of the valves is required.

3. Use the spanner wrench to loosen and remove the one-piece clamping disc/screw ("E"). Remove the old diaphragms from both heads ("G").

4. Remove the four pan head screws with M5 washers ("J") and remove the housing cover ("K") from the front of the pump body. If necessary, carefully use a small flat-bladed screwdriver to pry-off the housing cover.

5. Install the two PTFE (white color) diaphragms together with one TFM (translucent) diaphragm as shown in Figure E-1. Install with the ridges of the diaphragm convolutions as shown in the diaphragm stack cross-section inset.

   Note: Temporarily insert two of the head screws through the diaphragms and screw into the pump body to keep the position of the diaphragms as the clamping disc is tightened. Any stress applied re-aligning the diaphragm in the process of assembling the head will significantly reduce diaphragm life.

6. Check the threads of the clamping disc to insure that they are clean and free of debris. Apply a small amount of the breakable thread adhesive to the clamping disc threads and install.

7. Rotate the counterweight until the connecting rod is in mid-stroke and then tighten the clamping disc. **DO NOT OVER TIGHTEN THE CLAMPING DISC!**

   Note: Over tightening of the clamping disc will significantly reduce diaphragm life. Tighten enough to avoid contact with the head. If a significant amount of torque is required to tighten, first re-check to see if the threads are clear, then check that the connection rod support disc ("H") is properly seated on the connection rod. Over-torque of the clamping disc must never be a way to avoid contact with the head.

8. Remove the two temporary aligning screws and re-install the heads on to the pump body.

   Note: The correct head bolt torque range is 20-30 inch-pounds.

9. Turn the counterweight ("M") through at least one full revolution to check for smooth operation.

10. Re-install the housing cover and check the pump for correct performance.

VALVE REPLACEMENT PROCEDURE

Use the following procedure and Figure E-1 to replace the valve.

1. With the head off the pump, unscrew the socket head cap screws with M4 lock washers ("S") to remove the head lid ("T") and gasket ("V").

2. Loosen the single pan head screw, washers and nut ("P") and remove the two stainless steel reed valves ("Q"). If necessary, hold the nut in place with a nut-driver.

3. Lightly clean the valve seat area of debris or deposits with fine-grade steel wool. This area must be clean and smooth, without pits or scratches. Do not scratch the head plate. Finish the cleaning with alcohol and then air-dry the parts.

4. Lay the two replacement reed valves on a flat surface to the direction of any slight bend.

5. Lay the replacement reed valves in place, center bowed out (see valve installation), and tighten the pan head screw, both washers, and the nut. Be certain that the reed valves lay straight and smooth with clearance from the recessed edge to prevent sticking. If a reed valve curves away from the valve hole, remove the screw, flip the valve over and reinstall.

6. Match the holes of the PTFE head gasket ("V") with the head seal surface, install the head lid, and tighten the two center bolts with M4 lock washers first and then cross alternate tightening of the perimeter bolts. Re-tighten the two center bolts after the other bolts are tight.
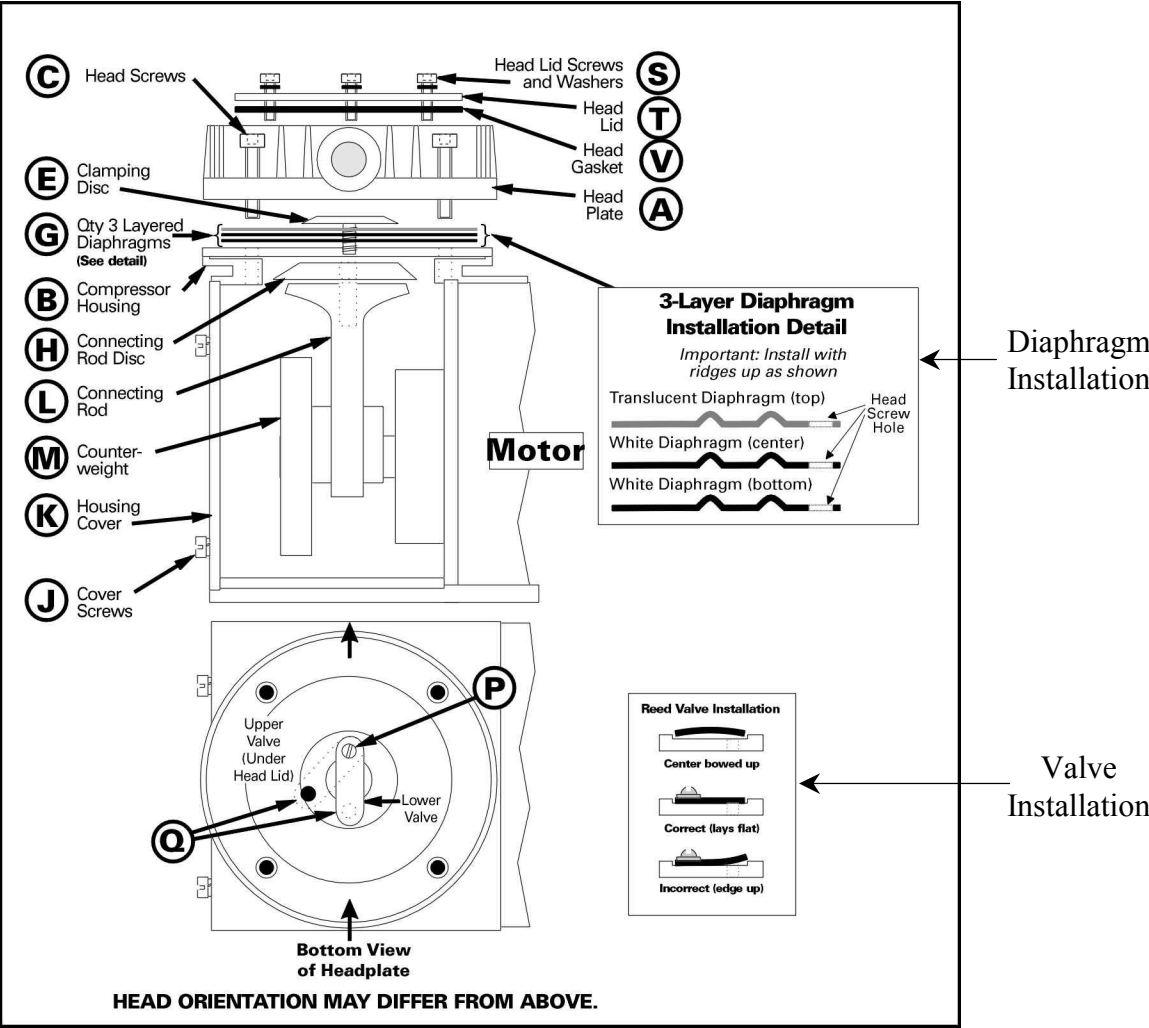
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Figure E-1 Vacuum Pump – Head Plate and Motor View